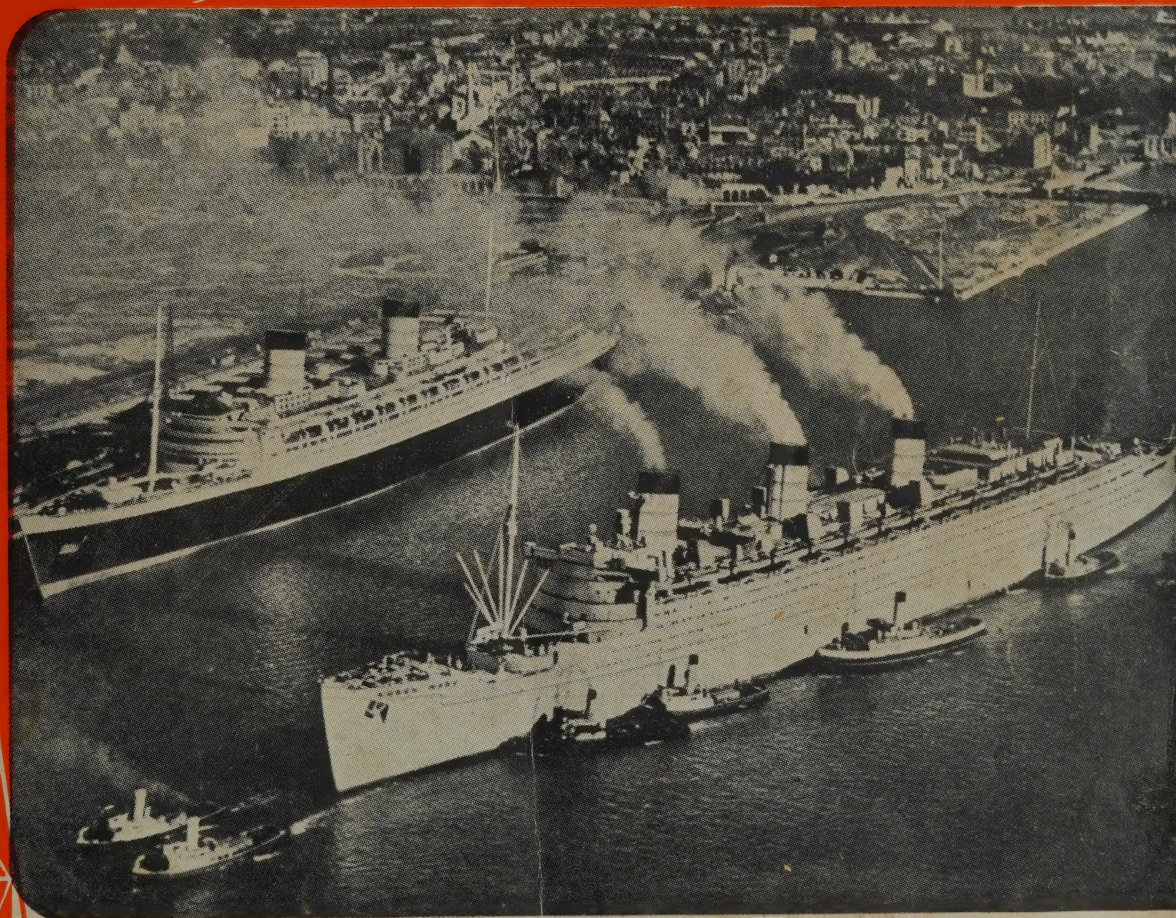


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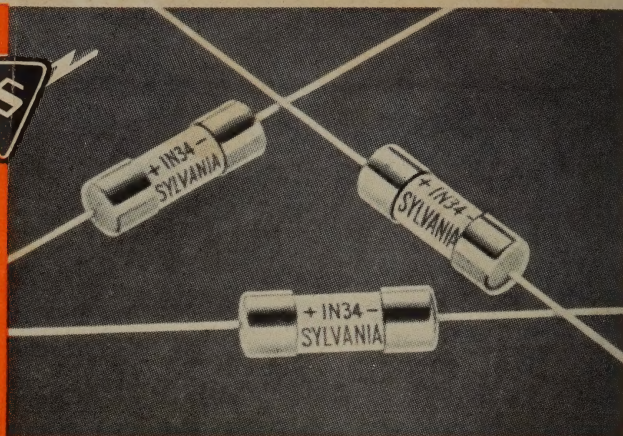
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RADIO and ELECTRONICS

Vol. 2, No. 3

June 1st, 1947

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OUR COVER:

This month's cover picture shows the Queen Mary entering the docks at Southampton, with the Queen Elizabeth berthed in the background. The latter is noteworthy for her extensive telecommunications equipment, which includes a passenger telephone service throughout the ship, which may be linked with shore telephone systems through a radio link while the ship is at sea, and the latest radio navigational aids. The photograph is printed here through the courtesy of the General Electric Company of England, who were responsible for the installation of the above equipment.

EDITOR'S NOTE:

We regret that, through the exigencies of space, we have been unable this week to include the due instalment of "Practical Trouble-shooting," which will be carried on in the July issue of "Radio and Electronics."

CORRESPONDENCE

All correspondence, contributions, and enquiries referring to advertising space and rates should be addressed to:—

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Box 22,

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BUSINESS ADDRESS:

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TUBE RATINGS AND THEIR USE

In the past, when the range of valve types available for design purposes was strictly limited, and when prices were high, the practice grew up in some quarters of using small tubes, beyond their ratings, rather than more adequate ones, conservatively operated. There may have been a certain justification for this practice at a time when the latter system was so expensive in terms of first cost and when certain values of power output could not easily be obtained without recourse either to gross overloading on the one hand, or to equally uneconomic under-running on the other.

Now, however, the situation is different, in that the designer of electronic equipment is faced with a multiplicity of tube types rather than a dearth of them, and may even be at a loss to know which to use for a given purpose, since so many apparently suitable types exist. There is certainly no justification in these days for working valves outside their rated capabilities, and yet it is still done—sometimes by industrial designers who might be expected to know better.

The importance of operating valves within their rated capabilities is much greater than may appear at first sight, and increases with every electronic device that goes out of the hands of the electronic engineer into those of the non-technical user. Electronic techniques, in spite of having proved their versatility and their ability to provide hitherto undiscovered solutions to technical problems, still suffer from certain disadvantages (which should be imaginary, but unfortunately are not always so) in the eyes of the user.

By far the most important hurdle is that of apparent unreliability. Many users of industrial electronic equipment are electrical engineers. The greater their age and technical responsibility, the greater is their reluctance, very often, to have anything to do with electronic methods. This state of affairs, though unfortunate, is understandable, for electronic tubes are not old enough yet for people to be unaware of their genuine unreliability in the early days of radio, which was virtually the sole application of electronics.

The fact is that valves may now be rated among our most reliable and trustworthy electrical devices, and the point we wish to make is that designers of electronic equipment have a responsibility not only to themselves, but to all actual and potential users of their equipment, to see that no possibility exists of failure due to improper operating conditions.

In general, the valve manufacturers supply numerous data on their products, giving, as they do, both maximum values for plate-voltage, grid-current, and so on, and sets of typical operating conditions for various classes of service. There are, however, a number of difficulties which normal valve data do not resolve. For instance, it is standard practice to use "receiving" tube types in transmitting applications for which they were not originally designed. The trouble here is that, although the manufacturers know quite well that this is the case, they take very few steps to provide ratings for receiving tubes in transmitter applications.

Similarly, many manufacturers fail to give absolute maxima for their tubes, receiving or transmitting, contenting themselves with so-called "design maxima," whose meaning is, to say the least, indeterminate.

Since the war a special problem has come very much to the fore—that of operating tubes under pulsed conditions. Though it may be known, in general terms, that this type of operation allows certain of the normal ratings to be exceeded for the duration of a pulse, who but the manufacturers is to know by how much, or for what kind of work-cycle?

The responsibility to which we have referred therefore devolves in large measure upon the valve manufacturers, and until they see fit to provide the designer with a good deal more information which takes modern problems into account, tubes will continue to be mis-used, and failures will be more frequent than need be.

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ELECTRONICS IN METEOROLOGY

THE FIRST OF A SERIES OF ARTICLES DESCRIBING ELECTRONIC DEVICES THAT ASSIST THE MODERN METEOROLOGIST

By R. A. EWING, B.Sc.

Meteorology, like other sciences, depends ultimately for its development on the accuracy and range of the observations upon which it bases its conclusions. In effect, each forecast is a scientific prediction, entirely similar to the predictions made in the experimental branches of physics. In addition to the disadvantage of not being able to control the experimental material with which he has to deal, the meteorologist, until recently, has had to base his conclusions on observations made only at the surface of the earth. The development of aviation has created an imperative demand for both observation and prediction of the behaviour of the upper atmosphere, and it is already clear that the evolution of jet-propelled aircraft will enormously increase that demand in the future.

It is in response to this demand that electronics has come to the aid of the meteorologist, and at least three new observational techniques based on the use of electronic devices have been put into operation within the last decade by most meteorological services throughout the world.

The first of these techniques uses an instrument known as a radiosonde, which is really a miniature automatic weather station. Observing devices in the radiosonde measure in turn the air pressure, temperature and humidity, or wetness of the atmosphere, and transmit these measurements to the ground station by means of a small battery-operated radio transmitter. The radiosonde, which weighs between two and three pounds, is carried aloft by means of a hydrogen-filled balloon measuring about six feet in diameter when at the earth's surface. Ascending at a rate of between 600 and 1000 feet a minute, the balloon expands owing to the reduction of atmospheric pressure with height, and at ten to fifteen miles up, when the balloon has expanded to more than twice its original size, it bursts. A small parachute then opens, and carries the instrument to the ground, when, if it is found, it can be recalibrated and used again.

Radiosondes may be of several different types, depending on the type of radio transmission used and how the meteorological measurements are converted into radio signals. Further details of the types of radiosondes in current use will be given in subsequent articles.

The second technique depends on the use of radio direction finding (R.D.F.) or of radar for determining upper wind speed and direction. Both these methods operate by tracking a hydrogen-filled balloon, which, after release, ascends into the free air and at the same time is carried along by the wind stream. The difference between these two methods depends on the position of the radio transmitter. With R.D.F. the balloon carries its own radio transmitter aloft, which in most cases is a radiosonde transmitter, while with radar the balloon carries a target to reflect the pulses of electromagnetic energy transmitted from the radar set on the ground. A fuller description of types of this equipment will appear in later articles.

The third technique is the location by R.D.F. of discharges of atmospheric electricity, which is sometimes given the name of "sferics," derived, of course,

from "atmospherics."

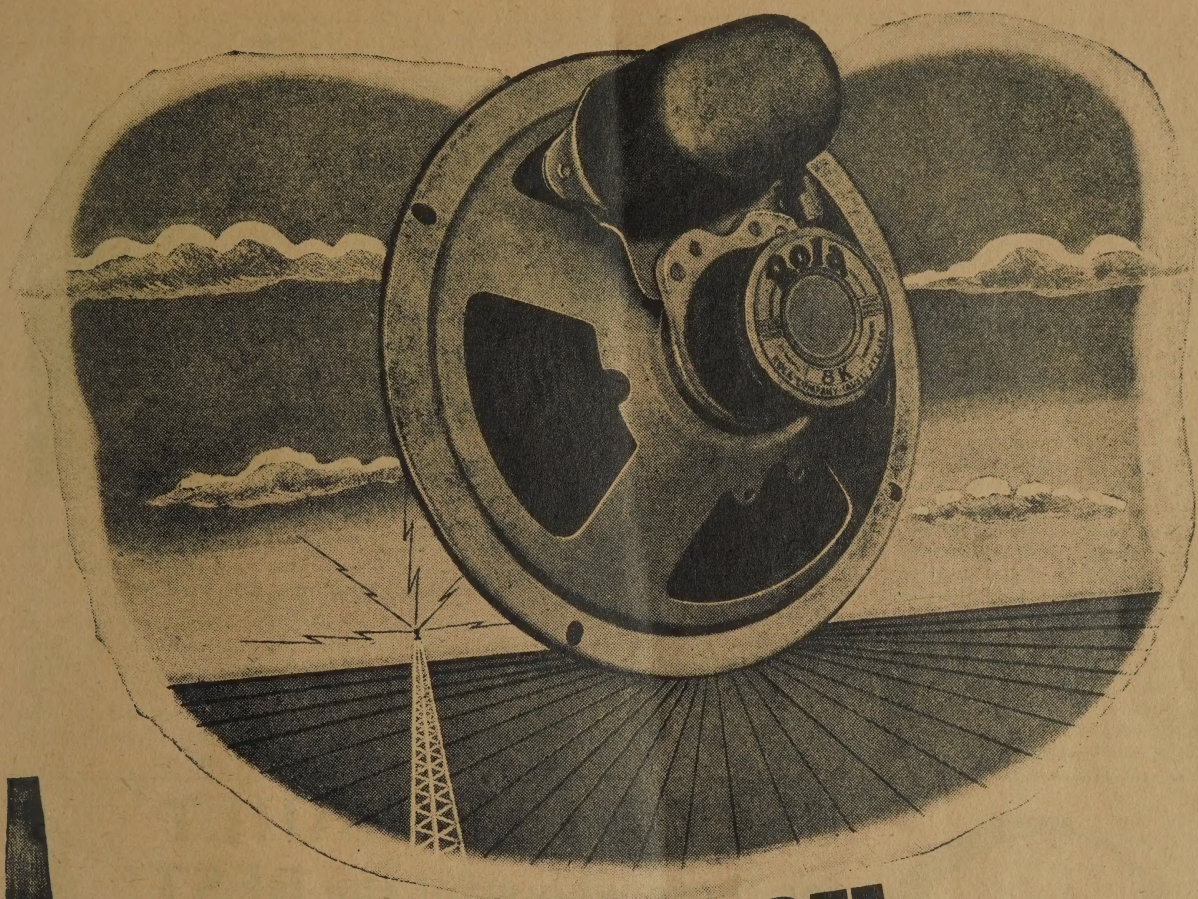
Discharges of atmospheric electricity give rise to static, and those which are of meteorological origin and significance are believed to be concentrated in the longer wavelengths. Hence, to locate these discharges, a network of low-frequency R.D.F. stations, each spaced a few hundred miles apart, is set up,



This photograph shows a radiosonde about to be released on a R.A.F. station in England. The instruments and transmitter are contained in the small "can" which is being adjusted by the operator in the foreground.

and simultaneous observations are taken on individual flashes of static. Plotting the bearings of the discharges from individual stations enables a fix to be obtained.

The expense, both in equipment and in manpower, in setting up these stations and the necessary communication links between the stations has rather limited the application of this technique, but in tropical regions, where these observations can be of very great use to the meteorologist in assisting him to



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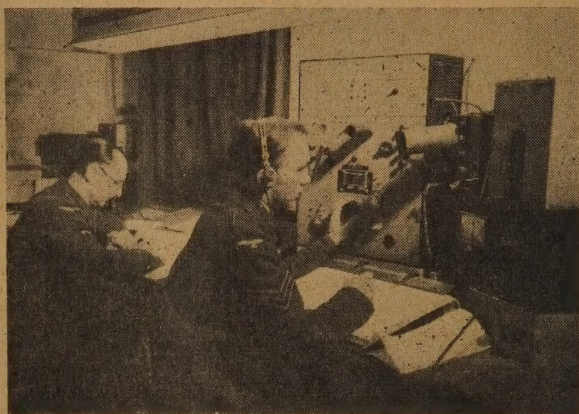
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locate and track tropical cyclones and storms, the cost is often justified.

The observations of pressure, temperature, humidity, wind speed, and direction in the free atmosphere can be obtained, of course, by other than electronic means. It is possible to take a barometer, thermometer, and hygrometer up in an aeroplane and make readings of these instruments as the plane ascends; while meteorologists for many years have followed hydrogen-filled balloons visually with special theodolites in order to determine upper wind speed and direction. However, observations so made are very limited in scope; very few aircraft have service ceilings above four or six miles, and most aircraft are grounded by bad weather, while clouds or rain limit very seriously the height to which a balloon can be followed by visual means. Hence, if regular meteorological observations in the free atmosphere are to be obtained, it is essential that they be made by electronic means.

Now, modern meteorological research has shown that such observations are essential to the understanding of the atmospheric circulation above the ground layers, and, further, only through such an understanding are improvements ever likely to be made in the accuracy and range of weather forecasts. However, apart from this long-term use, such observations are essential to the shorter-range forecasts required for the operation of aircraft, especially in oceanic regions. The upper winds are all-important during flight in determining the pay-loads that can be carried, while the upper pressure, temperature, and humidity patterns determine the upper cloud, weather, icing, and turbulence the aircraft will meet on its

flight. But, above all, these observations are essential to the local forecasting of terminal landing conditions.



This photograph shows the receiving end of the radiosonde system. The operator tunes in the signals from the air-borne transmitter and obtains values of temperature, pressure and humidity.

One of the greatest dangers to aircraft operation in an oceanic region is faulty terminal forecasting, particularly where night landings are involved. During the war, a large proportion of aircraft losses everywhere were due to weather, and most narrow escapes in the Pacific have been in the form of arrivals at (Continued on page 48.)

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VALVE CURVES IN CLASS A AMPLIFIER DESIGN

Although the valve manuals provided by most manufacturers give the bulk of the operating data necessary to use any tube for its recommended purpose, it is frequently useful to be able to work out the design of amplifier stages, using only the plate-current plate-voltage curves of the particular tube. This article explains how a great deal of information may be derived from the published curves.

It is often necessary to know the operating conditions for class A amplifier stages, where the manufacturer has not seen fit to supply resistance-coupled data, or when the only information available is in the form of a set of plate characteristic curves. Similarly, if tubes are to be used at plate-voltages lower or higher than the standard values for which operating conditions are given in the valve manuals, the correct circuit values can only be found in this way.

A knowledge of how to use the valve curves gives the designer or experimenter a greatly increased command over his working medium, the electronic tube, and allows him to perform design problems not covered in the standard data books.

This article is therefore presented in the hope that many who hitherto have simply passed over the pages of characteristic curves in their valve manuals will now make use of them to solve their valve problems—or at least some of them. The present article is confined strictly to class A amplifiers, because, although graphical methods exist for properly designing class B and class C amplifiers, these methods can not be used until a thorough understanding of the class A case has been obtained.

MANY USEFUL THINGS

By means of a ruler and a little simple arithmetic, in conjunction with the published curves, practically everything one needs to know about class A amplifiers can be discovered. Resistance-coupled, choke-coupled, and transformer-coupled amplifiers can all be dealt with, and the answers to be obtained number among them power output, percentage distortion, maximum voltage output, power dissipation in the tube, the coupling transformer primary, or load resistor, maximum grid voltage required for full output, voltage amplification, and yet others too numerous to mention. Before going on to describe how these things may be found, it is perhaps desirable to say a few words in a general way about valve characteristic curves.

VALVE CURVES

Valve curves are graphs showing how the various important quantities in connection with a particular type of valve are interrelated, and thus how the valve will perform when various voltages are applied to its electrodes. Perhaps the three most important things to know about a valve are its plate-voltage, its plate-current, and its grid-voltage. (We are limiting ourselves to a discussion of triodes for the moment.) These things are fundamental with respect to any valve. If at any instant we know all three of these things, we know what the valve is doing. If we know also what will happen if one of them is varied, we know not only what the valve is doing, but what it will do if we make any changes in its operating conditions. Now, valve curves represent the simplest way of expressing this information about a tube. For example, supposing we take a valve and some batteries and some meters, and measure the plate-current at a number of different plate-voltages, while keeping the grid-voltage fixed, we obtain

enough data to draw a good graph of plate-current against plate-voltage. This tells us exactly what the valve's plate-current will be for any plate-voltage within the range of our measurements as long as the grid bias remains the same. But the grid-voltage itself can be varied—it is when a signal is applied to the tube—so that in order to find out more about the tube's performance, we could change the grid bias to a new value, and repeat our performance. If now we plot this out we will have a completely new curve. Obviously it is impracticable to take plate-current-plate-voltage curves at all grid-voltages, because that would mean drawing an infinite number of curves, but it is possible to draw a fresh curve for every two volts change in grid bias, or every ten volts, whichever is most convenient. In this way we have a series or family of curves which specify completely the performance of the valve under any conditions of plate-voltage, grid-voltage, and plate-current.

Curves of plate-voltage against plate-current for various grid-voltages are known as the plate characteristic curves for the tube, and are perhaps the most useful kind of valve curve. However, the same information as is contained in the plate characteristic curves could have been presented in two other ways. First, if the plate-voltage were held fixed, and measurements were made of plate-current for various grid-voltages, it would be possible to draw a curve of plate-current against grid-voltage for a given plate-voltage. A family would be obtained in this case by repeating the measurements, drawing a fresh curve for a new plate-voltage. This kind of family is also frequently seen, and is usually called the mutual characteristic.

The third way of drawing the curves would be to hold the plate-current constant and draw curves of plate-voltage against grid-voltage for a series of values of plate-current. This type of family is called the constant current characteristic of the valve, and is usually drawn only for large transmitting valves.

It should be realised at the outset that any one of these three families of curves contains all the necessary information on the valve, and that the three are only different ways of presenting the same information. This is more easily seen when it is realised that if one possesses one of these families of curves for a given tube type, the other two can be drawn from it simply by drawing a new set of axes and transferring points from the old set of curves to the new one. The three sets of curves given here are obviously all of the first type, with various additions.

STATIC CHARACTERISTICS

The curves we have been discussing are all termed static characteristics, because they apply to the valve only under static conditions and when no circuit elements are in series with any of the tube electrodes. For instance, in Fig. 1 we have the plate-voltage applied directly to the tube without any intervening resistor, choke, or transformer winding. In Fig. 1 the various I_p - E_p curves have been labelled 1, 2, 3, etc.,

for convenience. Curve 1 is the curve for which the voltage applied to the grid of the tube is zero. Curve 2 applies when a small negative bias is applied. Curve 3 holds when twice this amount of bias exists, and so on. It will be noted that except for the portions near the plate-voltage axis, the curves are straight, parallel, and at equal distances from each other. In a theoretically perfect triode, the characteristics would be straight, parallel, and equidistant everywhere, and distortion would never occur.

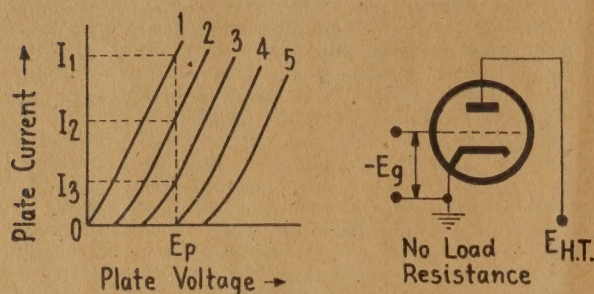


Fig. 1

Now, what happens when the grid-voltage varies, the plate-voltage being held constant? This can be ascertained by the method illustrated on Fig. 1. A perpendicular is erected at the plate-voltage E_p , which in this case equals the supply voltage $E_{h.t.}$. The curve 1 now tells us that when the grid-voltage is zero, the plate-current is I_1 . Curve 2 represents a small value of negative grid bias. Thus, where the perpendicular cuts this curve, the graph tells us that the plate-current will be I_2 milliamps. Again, curve 3 indicates that with twice the previous value of grid bias the plate-current is I_3 milliamps. The point now arises as to whether or not the above gives any information about the behaviour of the valve if the grid-voltage is continually varying, as when an alternating signal voltage is applied to the grid. For simplicity, assume that curve 2 corresponds to a grid-voltage of -1 , and that curve 3 represents one of -2 volts. Suppose, further, that a fixed bias of -1 volt is applied to the grid of the tube. In this event, the no-signal plate-current will be I_2 . Now, with the valve in this condition, an alternating signal voltage with a peak amplitude of $1v$ is applied to the grid. Thus, the grid-voltage will now vary from zero to $-2v$, at a rate governed by the frequency of the alternating input voltage. On the positive peak of the signal voltage, the grid-voltage reaches 0 volts, so that at this point the plate-current will be I_1 , while on the negative signal peak the grid voltage will be -2 volts, and the plate current I_3 .

This description enables us to visualise the effect of the signal voltage on the plate-current, but does not tell us how the variation in the latter produces an amplified voltage which may be passed on to another stage or to a speaker or pair of headphones.

In the example illustrated in Fig. 1, indeed, no signal voltage is produced at all, for the plate-current is the only thing in the plate-circuit that varies. As the graph shows, the plate-voltage E_p remains constant. The question is, how can the plate-current variations caused by the varying grid-voltage be made to give a useful result by way of an amplified version

of the signal?

The simplest way of achieving this result is to place a resistor in series with the plate as in Fig. 2. Now, as the plate-current varies, so will the voltage drop across R_L , and by choosing a suitable value for this component, the voltage variation thus brought about at the plate of the valve will be many times the voltage applied to the grid. This device is the well-known resistance-coupled amplifier, or at least the bones of it.

ADDING THE LOAD RESISTOR TO THE CHARACTERISTIC CURVES

As was pointed out earlier, the valve curves are drawn for the valve alone; that is, for a circuit like that of Fig. 1, where no resistance is placed in the plate, so that they no longer apply for the circuit of Fig. 2. How, then, can they be made to apply?

Suppose we have a plate supply voltage $E_{h.t.}$, and that this is applied to the tube as in Fig. 2, through a load resistor R_L . The first step is to work out a small sum according to Ohm's Law, namely:

$$I = \frac{1000 E_{h.t.}}{R_L} \text{ ma.}$$

We now find the point on the plate-current axis representing this current, and draw a straight line from this point to the point on the voltage axis representing $E_{h.t.}$. This line has been drawn on Fig. 2. Now, forgetting for the moment all about the valve and its curves, a little thought will show that on the two axes the line we have drawn represents a resistance of the value of R_L . A different value of R_L would be represented by a line, also starting from $E_{h.t.}$ but drawn to a different point on the current axis. A higher resistance would be represented by a line more nearly horizontal, while a lower one would show as a more nearly vertical line.

It is necessary to visualise clearly what this line means, and that it has no fundamental relation at all to the valve on whose curves it is drawn. This can be seen when it is realised whatever valve we may use, a given load resistance is always represented by a line of the same slope. In fact, it is the **slope** of the line, rather than the line itself; which determines what value of resistance it represents. The fact that we draw it through the point representing the $E_{h.t.}$ voltage that is to be used does not affect the slope in any way, any more than does the type of valve on whose characteristic curves it is drawn.

Let us see further how the line represents the behaviour of the resistance. The graph in Fig. 2 tells us that if a voltage $E_{h.t.}$ is applied to the resistor but that by some means no current is allowed to flow, the voltage across the resistor is zero, and both ends of it will be at a potential of $E_{h.t.}$ volts above ground. Now, if a current equal to I min. is allowed to flow through the resistor, the voltage at the lower end will be E max. From this it can be seen that the voltage across the resistor must now be $(E_{h.t.} - E \text{ max.})$. Obviously, the first case mentioned, where no current flows through the resistor represents an open circuit between the lower end of the resistor and earth. In the second case, a current of I min. can have been caused to flow only by placing in series with the resistor a second one, such that the current through the pair in series is I min. and the voltage drop across the added resistor is E max.

If now a lower resistance is placed in series with

R_1 , such that the current drawn is $I_{\max.}$, then the voltage across R_1 will be $(E_{h.t.} - E_{\min.})$ and that across the added resistor, $E_{\min.}$. Thus, if the added resistor varies in value from zero to infinity, or between any other stated limits, the line drawn across the graph represents the behaviour of the voltage drop across R_1 .

Now, if we consider the valve to be this variable resistor, and we draw the valve's plate characteristic curves on the same scale as has been used for the line

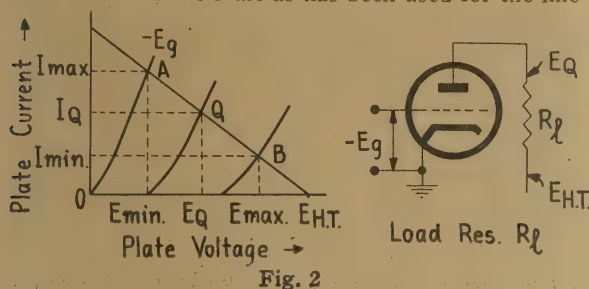


Fig. 2

representing the load resistor, then this combination of curves can be used to show what happens in the plate-circuit of the valve. Let us now consider Fig. 2 in its entirety. Here, for the sake of clarity, we have drawn only three of the valve's curves. The left-hand one for $-E_g = 0$, and two others, of which the right-hand one represents twice the grid-voltage represented by the middle one.

Suppose now that a fixed bias, equal to the grid-voltage indicated by the middle curve, is placed on the valve. Now this curve means that, with this value of grid bias, all possible combinations of plate-current and plate-voltage for this particular tube must be represented by points on this curve. Now, considering the straight line, we found that any condition of voltage across and current through R_1 can be represented by a point on this line. Therefore, the point where the two lines intersect must represent the plate-current and plate-voltage of the valve, because the plate-voltage is represented by one point on each of these lines, and the point where they cross is the only one which satisfies this condition.

Thus the usefulness of the straight line in conjunction with the valve curves begins to be apparent, for with a grid bias represented by the middle curve, and no signal applied, the graph now tells us (1) that the voltage at the plate of the valve is E_q , (2) the plate-current is I_q , (3) the voltage drop across R_1 is $(E_{h.t.} - E_q)$.

Because it represents the load resistor R_1 , the straight line is called the **load line**, and since the point Q represents the conditions under which the valve works when no signal is applied to the grid, it is called the **operating point**, or sometimes the **quiescent point**.

APPLICATION OF A SIGNAL

In the case where no load resistor was present, we found that varying the grid-voltage around the operating point bias voltage caused only a variation in plate-current, and no change in plate-voltage. In this case, however, the application of a signal to the grid causes both to vary simultaneously. Furthermore, since, as we have seen, the voltage at the low potential end of R_1 is always represented by a point on the load line, points on this line must necessarily represent the plate-voltage of the tube. This is true be-

cause the plate is tied electrically to the low potential end of R_1 and must always be at the same voltage at this point on the resistor. Thus, the load-line must give us the plate-voltage and plate-current of the tube if we know the value of grid-voltage at any time.

For example, suppose that the centre curve on Fig. 2 represents a fixed bias of $-2v$, and that the right-hand curve therefore indicates a grid voltage of -4 . When now a signal of $2v$, peak is applied to the grid, the latter will swing between $0v$, and $-4v$. At the positive peak of the cycle, the plate-current and voltage will be given by the point A, on both the load-line and the curve for $-E_g = 0$, simultaneously. At this point the plate-current will be $I_{\max.}$ and the plate-voltage $E_{\min.}$. At the negative peak of the input cycle the tube will be at the point B, with a plate-current of $I_{\min.}$ and a plate-voltage of $E_{\max.}$.

Thus, over the complete cycle of input voltage applied to the grid, the plate-voltage varies from $E_{\min.}$ to $E_{\max.}$, so that the peak signal voltage at the plate is $E_{\max.} - E_q$, or, which is almost the same thing, $(E_q - E_{\min.})$. Since $(E_{\max.} - E_q)$ can easily be in the vicinity of 50 or more volts, we have achieved an amplification of 25 times in the signal-voltage.

DISTORTION

Since the object of an amplifier is to produce at the output an enlarged replica of the wave-shape supplied at the input, simply to amplify the latter is not sufficient. If the wave-shape of the output is not identical with that at the input, distortion is said to have occurred. The plate family of curves shown in Fig. 2 also gives a clue as to how this distortion can take place. Supposing that our input voltage is a

(Continued on page 47)

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ZL3AW AT HOME

A short time ago ZL3AW while in Wellington visited us in person, and told us something of his station, at Kaiapoi. How the other fellow goes about things, especially in the "ham" world, is always of interest to others, so we asked him to give us some photographs and a short write-up on his outfit.



At the left is a general view of 3AW's shack, with the man himself at the operating position.

Note the "P.P.I." for the rotatable array, above the operating bench.

Right: ZL3AW pulls out one of the transmitter racks to demonstrate the carved panel construction.

Not everyone has the time or the facilities to produce as fine looking a station as this one, but we feel sure that our "ham" readers will be interested in 3AW's set-up, if only by way of "window-shopping," as it were.

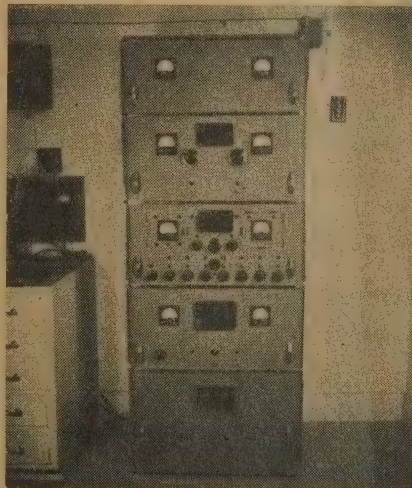
The transmitter is rather original in design. It is built rack and panel style, finished in grey crackle and chromium. There are five panels, each capable of being drawn out without any wires having to be disconnected, as plugs are fitted to the rear of the

the 20m. band. The 812 stage is excited from the band-switching unit, and through the use of relays can be changed from one band to another very rapidly. The band-changing switch makes all the necessary alterations as follows:—

- (1) Provides plate supply from the modulator.
- (2) Switches off 813 filament; and turns on an 807 buffer.
- (3) Switches on the 600v. supply for the buffer.
- (4) Changes the excitation from the 813 to the 807,

Left: General view of the front of the transmitter. A detailed description of the panel functions is given in the text.

Right: The Oregon lattice mast and three element array for the 10m. band. The steel pipe driving shaft can be seen in the centre of the mast, and the feeders can just be discerned running up the left-hand front main member.



trays to make all connections. When required, any panel may be withdrawn instantly, but the front is so constructed that, at a glance, one would not know that the whole five panels were not bolted together. The bottom panel contains the 1500v. power supply for the final and modulators, the 400v. supply for the crystal oscillator and doublers, the 700v. supply for an 807 buffer, and relay, bias and filament supplies.

The next panel contains the speech amplifier, modulators, and high-voltage relays.

at the same time reducing the output and altering all indicator lights.

- (5) Alters the impedance ratio of the modulation transformer to take care of the different modulator loading of the 812's.

A comprehensive metering circuit is used, which has indicator lamps to show which circuits are being metered, and to show which exciter stage is in use. Inspection windows are provided on each panel and

(Continued on page 47)

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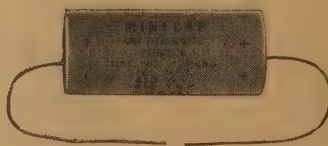
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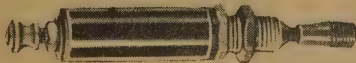
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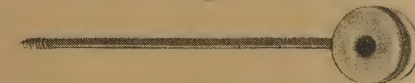


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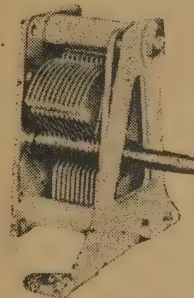
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THE ENLARGED 6A3 AMPLIFIER

Since the first issue of "Radio and Electronics," in which we gave a design for a high-quality 6A3 amplifier, we have received numerous inquiries as to how this amplifier may be modified in order to provide enough voltage gain for a low-level microphone. Partly for this reason, and partly to incorporate a rather more adequate phase-inverter stage, we have re-designed the voltage stages of the original version, with the following result.

Many readers have written appreciative letters with regard to the performance of the original "High-quality 6A3 Amplifier," which appeared in our maiden issue, dated April, 1946. In its original form, the amplifier was entirely suitable for use from a gramophone pick-up or radio tuner, but had insufficient gain for a low-level microphone, either crystal or dynamic. In addition, the phase-inverter circuit was working right to the limit of its capabilities in order to load the 6A3's to full output. It was decided, therefore, to redesign the voltage amplifier stages (1) to give two inputs, one suitable for low-level microphone, and the other with enough gain to handle the average tuner or pick-up output; (2) to provide an ample margin of driving voltage for the 6A3's, so as to give lower distortion at maximum output, or greater output for a given distortion level.

THE CIRCUIT IN DETAIL

As in the previous amplifier, self-biased 6A3's are used, which have a rated output of 10 watts at 5 per cent. total harmonic distortion. This part of the circuit is quite conventional and requires little comment. On the diagram, R_{16} is the cathode bias resistor for the 6A3's, and R_{17} and R_{18} form a centre-tapped resistor across the 6A3 filament winding.

The phase-inverter has the very well-known paraphase circuit, and uses a 6N7 tube. In the diagram the halves of the 6N7 have been drawn as separate valves. The connection between the cathodes has been drawn dotted, since in this type the cathodes are joined internally, so that in practice R_{11} is connected from the single cathode terminal to earth. The left-hand half of V_2 acts as a straightforward voltage amplifier resistance-capacity coupled to V_3 . Likewise, the right-hand half of V_2 is resistance-capacity coupled to V_4 . The only peculiarity of the circuit is that the right-hand triode of V_2 obtains its input voltage from the output of the left-hand half, via the potentiometer R_{13} . Thus, since the voltage at the grid of V_4 has passed through one more stage than has the voltage at the grid of V_3 , these two voltages will be exactly out of phase with respect to each other. For proper push-pull operation, the signal voltages at the grids of V_3 and V_4 must not only be out of phase, but also equal in amplitude. Hence the inclusion of R_{13} , which enables the output of the two halves of V_2 to be exactly balanced with respect to output amplitude. The gain through each half of V_2 is approximately 22 times, so that for the right-hand half to give the same output voltage as the left-hand half, the former must be provided with one-twenty-second of the total output voltage of the latter. The values of R_{12} , R_{13} , R_{14} have been so proportioned that R_{13} gives a fine adjustment without getting outside the required range. It would have been possible to substitute a single 0.5 meg. potentiometer for this chain of resistors, but this would have

made the adjustment process more difficult to perform. In spite of the fact that R_{11} is unbypassed, there is no negative feedback in either half of V_2 , since when the halves are balanced, the signal currents through R_{11} cancel out, so that no signal voltage at all is developed across R_{11} .

Since the 6A3's each require a peak signal voltage of approximately 45 volts for full output, and the gain of each half of V_2 is 22 times, the peak input signal at the grid of V_2 is approximately 2 volts. This might be small enough to handle the output of some pick-ups and tuners, but current practice is to provide more gain than this. Doing so takes care of the likelihood that the amplifier will be used with a pick-up which has quite a small output voltage, or with a normal pick-up which has an equaliser connected after it.

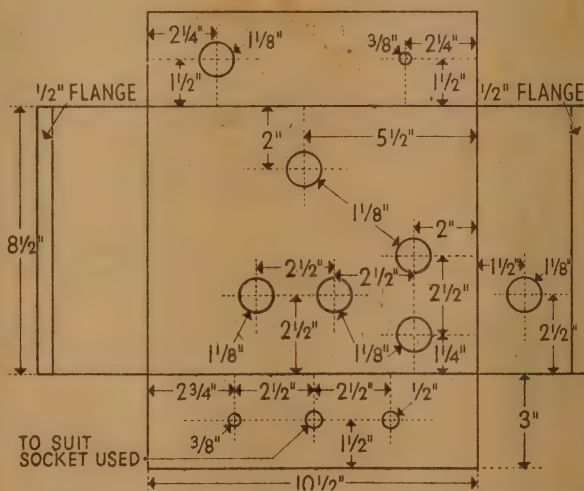


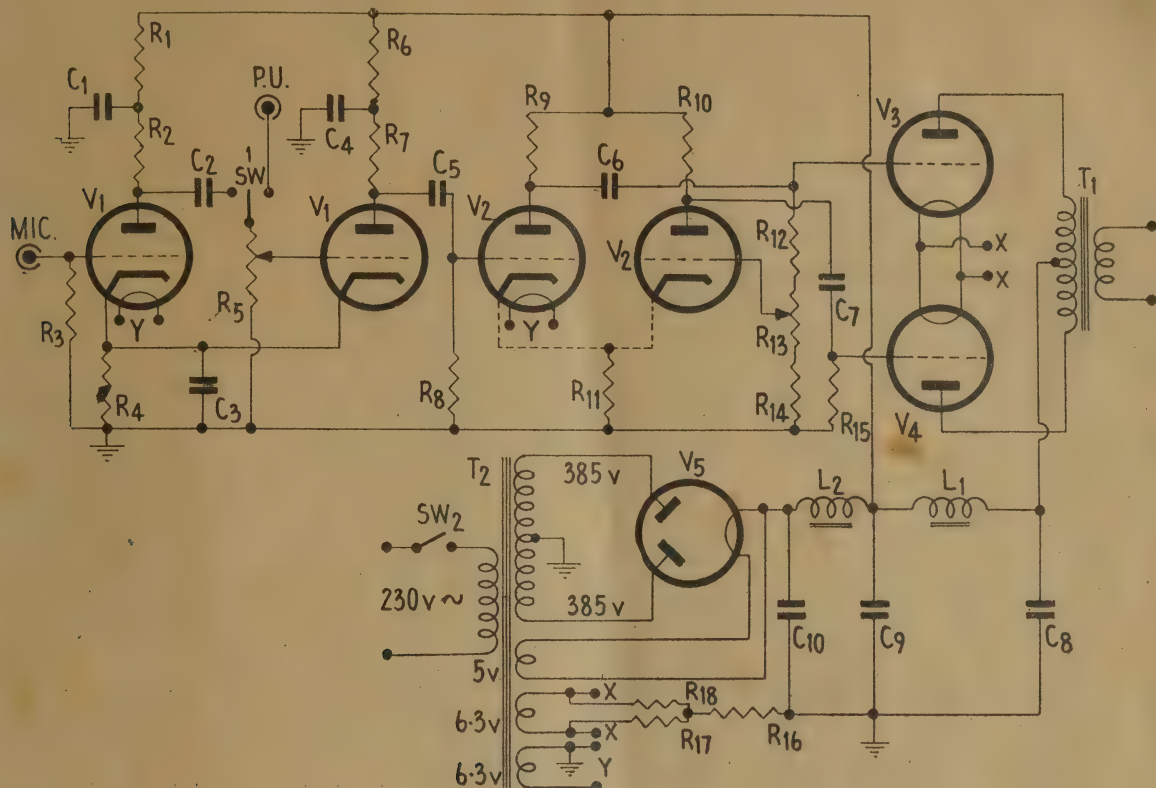
Diagram showing dimensions of the chassis for this amplifier.

It has become quite common in some quarters to cast aspersions at the straight paraphase circuit which has been used here, on the score that one side of the following push-pull stage must contain unbalanced distortion products. This is said to arise because in our case, V_4 has the distortion of both halves of V_2 fed to it, while V_3 has only the distortion of the first half of V_2 to handle. This argument seems quite sound, and, in fact, is so, on the assumption that the two sides of V_2 ARE delivering a distorted output. What is often overlooked, however, is the fact that if an amplifier as a whole is properly designed, the output stage starts to overload long before any appreciable distortion is produced in the stages which precede it. If such is the case, then

the distortion in each half of V_2 is negligible, and the objection can no longer be considered valid.

THE INPUT STAGES

The remaining valve in the amplifier is a 6SN7.



$R_1, R_2, R_6, R_7, R_9, R_{10} = 100k. \frac{1}{2}w.$

$R_3, R_8 = 250k. \frac{1}{2}w.$

$R_4, R_{11} = 1500 \text{ ohms } \frac{1}{2}w.$

$R_5 = 250k. \text{ pot.}$

$R_{12}, R_{15} = 500k. \frac{1}{2}w.$

$R_{13} = 25k. \text{ pot.}$

$R_{14} = 10k. \frac{1}{2}w.$

$R_{16} = 750 \text{ ohms } 10w. \text{ wire-wound.}$

$R_{17}, R_{18} = \text{Each two } 50 \text{ ohms } \frac{1}{2}w. \text{ in parallel.}$

$C_1, C_4, C_5, C_6, C_{10} = 8 \text{ mfd. } 450v. \text{ electro.}$

$C_2 = 0.01 \text{ mfd.}$

$C_3 = 50mfd. 50v. \text{ electro.}$

$C_5, C_6, C_7 = 0.1 \text{ mfd.}$

$T_1 = \text{Output transformer, } 5000 \text{ ohms p.-p. to v.c.}$

$T_2 = \text{Power transformer, } 385-0-385v. 120 \text{ ma., } 5v. 3 \text{ amp., } 6.3v. 3 \text{ amp., } 6.3v. 4 \text{ amp.}$

$L_1 = 750\text{-ohm speaker field.}$

$L_2 = 20 - 30H. 120 \text{ ma.}$

$V_1 = 6SN7\text{-GT.}$

$V_2 = 6N7.$

$V_3, V_4 = 6A3.$

$V_5 = 5Z3.$

$SW_1 = \text{S.P.D.T. toggle switch.}$

$SW_2 = \text{A.C. on/off switch.}$

In this circuit, the maximum output of each half of V_2 is 111 volts peak. This means that less than half the maximum is being used at the point where the output stage starts to overload. For this reason, distortion in V_2 will be negligible, even at the full output of the amplifier.

Another alleged disadvantage of the circuit is that the frequency response to each side of the output stage will also be unbalanced. This argument certainly holds at extremely low and extremely high frequencies, but the unbalances at 30 c/sec. and 20000 c/sec., if calculated, will be found to be so slight as to be entirely negligible.

In fact, the paraphase circuit has been used by many designers for a number of years with entirely satisfactory results, and we have no hesitation in including it in a circuit of ours.

V_1 , each half of which is used as a resistance-capacity coupled voltage amplifier. Two inputs are shown, one to the grid of the left-hand half of V_1 , and the other to the grid of the right-hand half. No arrangements have been made to provide fading from one input to the other, but instead SW_1 is arranged either to place the halves of V_1 in cascade, for a low-level microphone, or to disconnect the output of the first stage and substitute the pick-up, or high-level microphone, which is fed directly to the second half of V_1 . Each stage of V_1 has a voltage gain of 14 times. Thus at the input labelled "P.U." a signal of approximately 0.14v. peak fully loads the amplifier. This input terminal therefore has more than enough gain for the average pick-up, even if it is followed by an equaliser.

The "Mic." input terminal requires an 0.001v. peak,

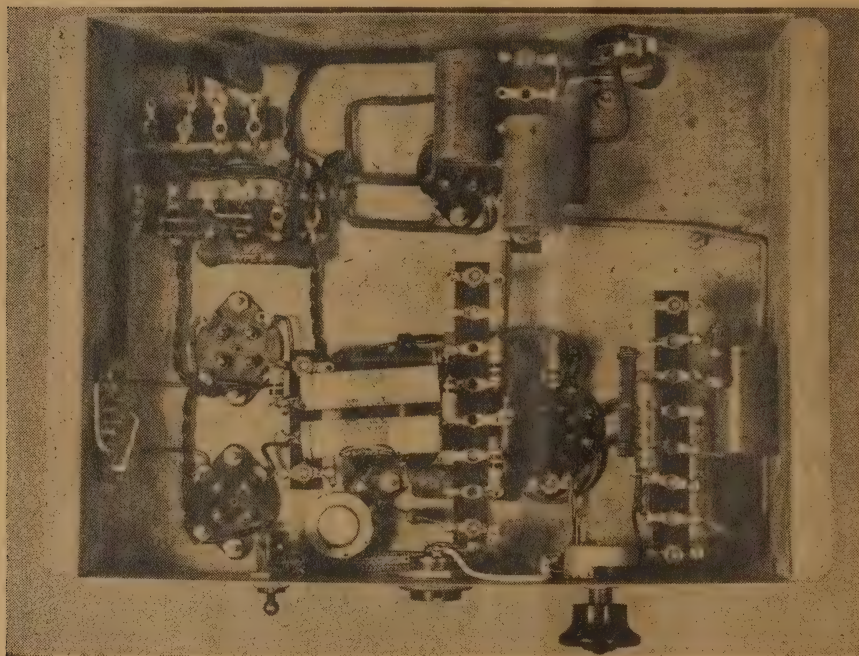
and this is ample for any low-level microphone that is likely to be found in general use.

Since the signal handled by the first section of V_1 is so minute, there is no possibility of its overloading under any microphone input conditions. For this reason there is no necessity for a gain control in the grid circuit of this stage. Thus R_5 acts as the volume control whether SW_1 is switched to the pick-up terminal or the pre-amplifier stage.

It should be noted that R_1 acts as the common cathode resistor for both halves of V_1 .

common coupling through the power supply impedance.

In case this should seem a poor method of ensuring stability, it should be pointed out that the gain reduction effect of C_2 is only 3 db. at 64 c/sec., so that there will be no impairment of voice quality. In fact, for voice work under some conditions, there would be a distinct advantage in reducing C_2 even further. An example of this would be in using the amplifier as a modulator or driver for a high-powered modulator. The voice frequencies below



Under-chassis view of the enlarged 6A3 amplifier. Note that the construction is very similar to that of the previous amplifier. In this case, though, the toggle switch is used to throw the input from one channel to the other. All the resistors and condensers associated with the 6SN7 except the input potentiometer and one grid resistor are mounted on the 8-lug piece of terminal strip at the right front of the chassis. The 6N7 socket is hidden under the two 6A3 grid coupling condensers.

DECOUPLING CIRCUITS •

The decoupling filters, $R_1 C_1$ and $R_6 R_4$, should on no account be omitted, as they form extra H.T. filtering for the low-level stages, and at the same time help to prevent motor-boating, which will certainly occur when all stages are in use if the decoupling is omitted. Similarly, the comparatively low value of C_2 with respect to R_5 should be strictly adhered to. If a larger condenser is used in the position of C_2 , there is a strong possibility of motor-boating in the high-gain position of SW_1 . The reason for this is to be found in the high impedance of the power supply. If such an amplifier were run off a battery H.T. supply, a comparatively small decoupling filter would be sufficient to prevent all possibility of low-frequency oscillation, owing to the very low internal impedance of the battery supply. However, in any power which uses a speaker field winding as a smoothing choke, the high resistance of the filter system makes it very difficult to eliminate all traces of low-frequency instability. For this reason, the low-frequency response of the first stage is purposely attenuated by making C_2 smaller than usual. Thus, the gain of the whole amplifier at frequencies in the region of five to ten cycles per-second is reduced to an extent which prevents oscillation in spite of

about 200 c/sec. add very little indeed to intelligibility, but tend to overload the transmitter long before the higher speech frequencies, which really carry the intelligence. If, then, the frequencies below 200 c/sec. are strongly attenuated before the modulator stage is reached, the net result is an effective increase of percentage modulation for the more important middle frequencies. The voice quality will be crisp, clean, and easy to copy, although it will have lost something if looked upon as a reproduction of the operator's voice.

CONSTRUCTION OF THE AMPLIFIER

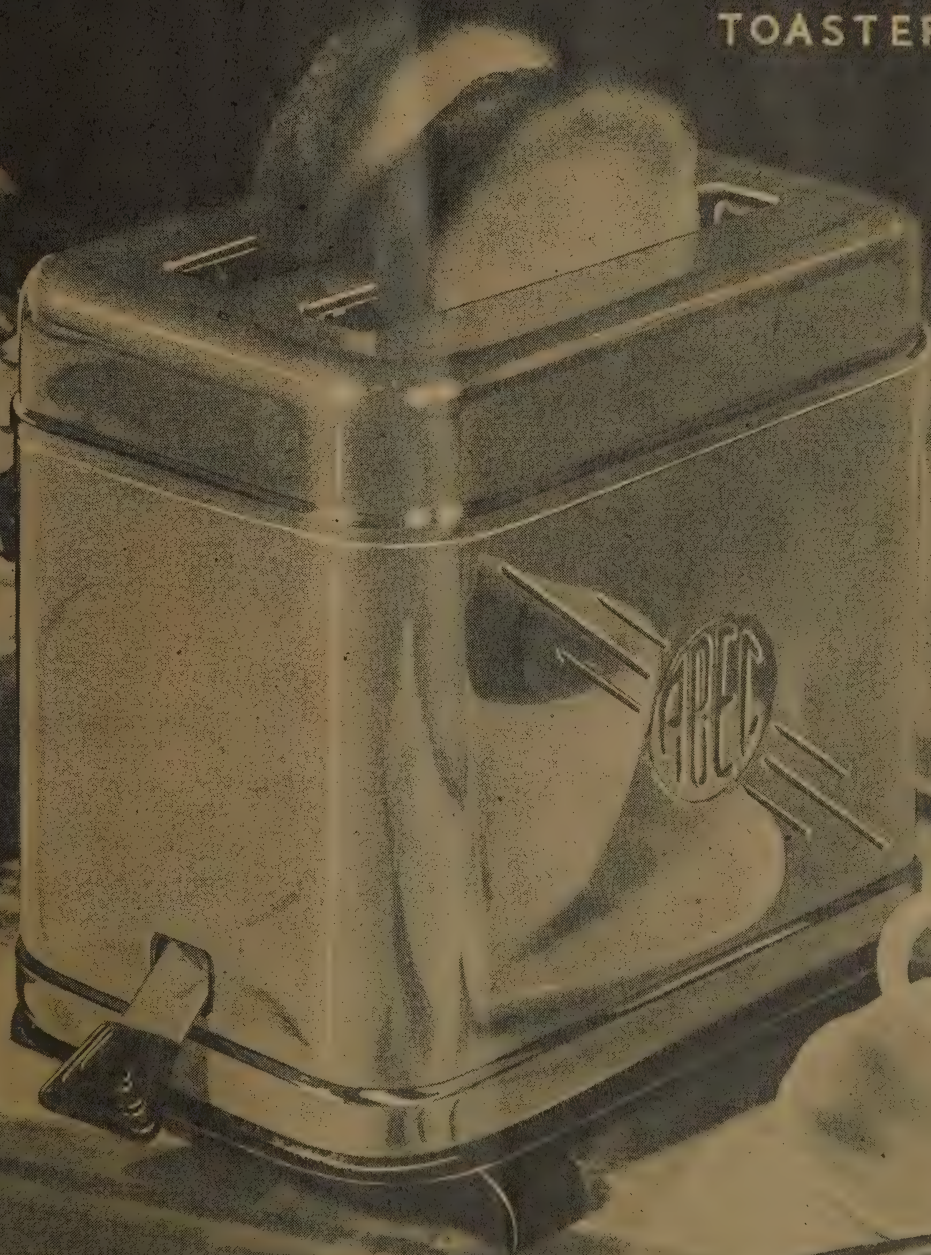
The construction of the amplifier is exactly similar to that of the original version, and uses the same chassis design, which is reproduced here. The power transformer occupies the back right-hand corner of the chassis, next to the rectifier valve, on the other side of which is the choke L_2 . In front of this row of components are, from left to right, V_1 , V_2 and V_3 and V_4 . The holes in the front of the chassis, reading from left to right, accommodate the volume control, R_5 , the three-way shielded socket for the two inputs, and the switch SW_1 . If desired, of course, separate shielded sockets and plugs can be used for the inputs.

UNDER-CHASSIS WIRING

The wiring of the amplifier is quite conventional

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and is simple to carry out, using the terminal-strip method for most of the components. The photograph shows the manner in which the components were mounted. At the back of the chassis, mounted about an inch from it, is a strip carrying the three smoothing condensers. The lugs at the "high" ends of these components are used to terminate the leads from the rectifier filament, the choke, and the speaker field winding. The small strip at the left-hand back of the chassis terminates the 230v. leads from the power transformer and the power plug. The six-lug strip in front of this holds R_{16} , R_{17} , and R_{18} , and terminates the 6A3 filament winding and the main heater winding of the power transformer.

The small strip between and to the right of the 6A3 sockets is used only to provide tie-points for the coupling condensers C_6 and C_7 . Near this can be seen the phase-inverter adjustment potentiometer R_{13} .

Since the overall gain of the amplifier is so high, it is essential to run the leads from the input socket to the input switch and to the first section of V_1 in shielded wire. Ordinary "grid wire" can be used for this purpose, or else shielding braid may be placed over a piece of "spaghetti" and a bit of hook-up wire run through the latter. Since each lead is only a few inches in length, there will be negligible high-frequency loss, while hum pick-up from the power transformer and feedback from the output stage will be effectively eliminated. Similarly, the output lead from the first half of V_1 to the switch should also be shielded.

INITIAL ADJUSTMENT

Since R_{13} has been included so that proper balance of input voltages to the push-pull stage may be obtained, it is necessary to understand fully the effects which can occur when R_{13} is varied.

At first sight, it might be considered that the easiest way to balance the outputs of the paraphase stage would be to place an A.C. voltmeter first across one half of the output transformer primary, and then across the other half, and note whether the two readings are the same. However, this method is quite insensitive and can be most misleading. The reason for this is that even if, say, V_4 is not operating at all, and a meter is placed across the V_4 half of the output transformer, an almost equal output voltage will be indicated to that obtained when the meter is across the other half of the transformer, into which V_3 actually is working. T_1 in this case acts simply as an auto-transformer, irrespective of whether one side of the push-pull is working or not. If the measurement is to be made at the output transformer primary, it will be necessary to remove V_3 while measuring the output voltage of V_4 , and vice versa. The test is carried out as follows: The voltmeter is clipped across the V_3 half of the output transformer primary, and a constant amplitude tone from an audio oscillator is fed into the amplifier input. The volume control is set to give a moderate output, easily read on the meter. V_4 is now unplugged for long enough for the meter reading to be taken, and then replaced in its socket. Without altering the volume control setting, the meter is changed over to the other half of the output transformer, and V_3 is removed. R_{13} is now adjusted so that the meter reading is identical with the previous one. V_3 is now replaced, and the balancing operation is complete.

OTHER SOURCES

If an audio oscillator is not available, the next best thing is to use a 50 c/sec. voltage obtained from the main heater winding. The unearthened side of this winding is temporarily connected to the pick-up input terminal, and the volume control set for a moderate output as before.

The balancing operation is best carried out with a moderate frequency such as the 400 c/sec. found in most R.F. signal generators, but the 50 c/sec. from the winding will do equally well.

If an A.C. voltmeter is not available, the amplifier can still be balanced with the aid of a pair of headphones. This method depends upon the fact that when V_2 is exactly balanced, there is no signal voltage across R_{11} . The method is therefore to apply the moderate input to the amplifier, as before, and to connect the headphones in series with an 0.1 mfd. condenser, across R_{11} . The balancing control is now adjusted for minimum output from the headphones. In practice no absolute zero signal may be observable on account of the high sensitivity of the phones and of the effect of small stray capacities, allowing them to pick up a small residual signal. However, this method of balancing is quite accurate, as can be found afterwards checking by the voltmeter method.

One point to note is that testing across R_{11} will ensure that equal signals are delivered to the grids of V_3 and V_4 . As long as these tubes are accurately matched, this will give equal signals in the plate circuits, too, but an unbalance can still occur with this method of testing if V_3 and V_4 are not identical as to characteristics.

Needless to say, the better balanced a push-pull stage, the better will be its performance, but it should be pointed out that unbalances of the order of 5 or 10 per cent. can certainly not cause enough harm to be noticeable on a listening test. However, if one wishes to be particularly fussy about this point, it should not be difficult to obtain a matched pair of 6A3's by the simple expedient of asking the salesman to check them on his valve tester. A pair should be picked which give identical readings on the tester for either emission or mutual conductance, whichever the tester measures.

It is for this reason that balancing the paraphase circuit by the first method to be outlined is preferable to the second. The most important thing is to have amplitudes balanced at the plates of the 6A3's, and this is what the first method ensures, irrespective of whether the tubes are exactly matched or not. A small unbalance in the paraphase stage does no harm at all, since hum and harmonics that may be generated in this stage are not balanced out until the signal is passed through the output transformer.

We have enlarged upon the subject of balancing because it is quite an important one in push-pull circuits, and this amplifier is capable of being balanced exactly. No re-balancing will be necessary unless a new 6N7 or new 6A3's are installed, and then only if the latter are not balanced between themselves.

Although the present amplifier has a slightly more complex circuit than our original one, which proved so popular, it is no more difficult to construct, and for a small additional outlay in resistors and condensers is much more versatile and has a better overload characteristic.

(Continued on page 48.)



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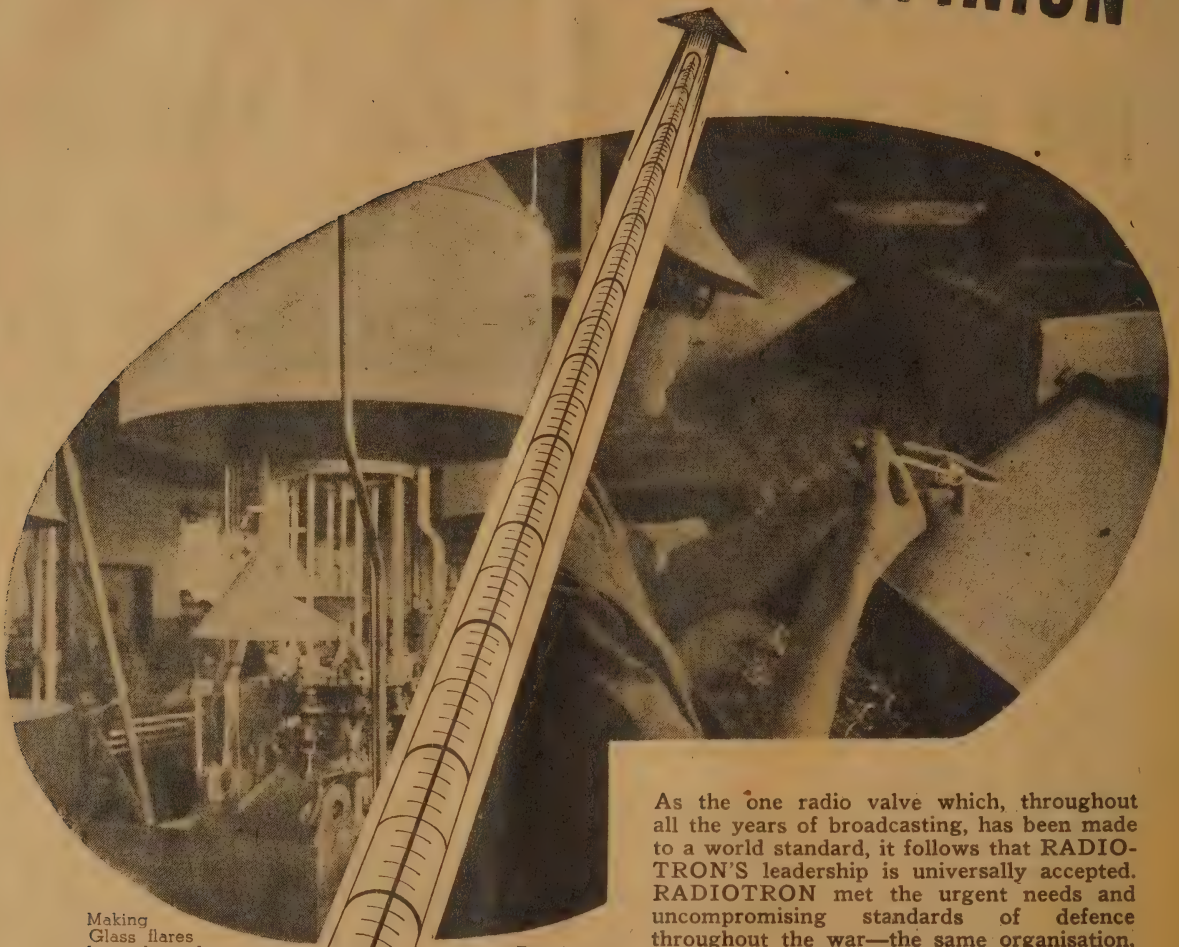
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It should be mentioned that no alterations in the circuit constants can be made without upsetting either the output stage grid bias, the S-meter, or both. R_{42} and R_{43} , as well as R_{51} , determine the bias resistance for V_{11} .

CONSTRUCTIONAL DETAILS

Having outlined the detailed design of the stages, we proceed now to the construction of the set. In the last instalment we gave working drawings for the required chassis and front panel. The holes which accommodate the control knobs are clearly shown, and are used as follows: The four controls along the bottom from left to right are, tone, noise suppressor on/off switch, manual gain control, A.V.C. on/off switch, and audio volume control. Directly above the A.V.C. switch, and in a line with the centre of the S-meter hole, is the $\frac{3}{8}$ in. hole for the B.F.O. pitch-control shaft. This was accidentally omitted from the front panel design.

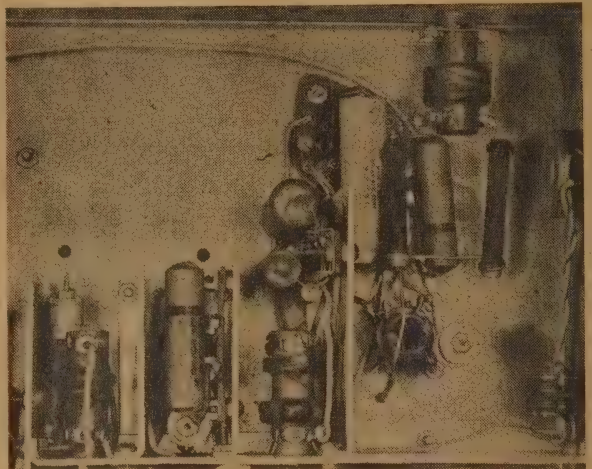
Looking at the diagram of the chassis itself, the valve socket holes are as follows: Back row, reading from left to right, we have V_{12} , V_{11} , and V_{10} . The next row, reading from right to left, contains V_6 , V_5 , and V_4 . The third row, from right to left, has V_7 , V_8 , and V_3 , while along the front, from right to left, are V_9 , V_2 , and V_1 . The four-gang condenser is mounted between the V_1 socket and the V_2 socket in such a way that the shaft comes out in line with the hole "A" on the front panel. The mounting of the power transformer, I.F. transformers, and B.F.O. coil can be seen quite well in the top chassis view of the completed set, given in the first instalment of this article. In this illustration the B.F.O. pitch-control condenser may be seen directly behind the B.F.O. can, which is the one nearest the front of the chassis and next to the meter. In the illustration the first R.F. stage, V_1 , can be seen to the right of the condenser gang, enclosed in its shield. Directly to the left of the power transformer is the first I.F. transformer, mounted in line with the rest of the signal I.F. chain. The 6SK7 tube is almost, but not quite, hidden behind the dual electrolytic smoothing condenser. At the end of this row can be seen V_6 , the detector and noise limiter tube, and to the right of it is the third I.F. transformer. Directly in front of this (moving towards the meter) is T_8 , the A.V.C. amplifier output transformer. Along the back of the chassis can be seen the 6SJ7 first audio, the 6V6-GT output tube and the 80 rectifier. On the left-hand side of the gang can be seen the tops of V_9 , the second R.F. stage, and the shield of V_3 , the oscillator-mixer.

UNDER-CHASSIS SHIELDING

Perhaps the most important thing about the under-chassis lay-out, which is shown here in two photographs, is the arrangement of the baffle-shields, which are used to isolate the various parts of the circuit from each other. These shields are not very readily picked out in the photographs, so we have drawn a diagram showing a plan view of the underneath of the chassis, complete with all its baffle-shields. If this is used in conjunction with the photographs, readers should have no difficulty in deciphering the lay-out.

These shields should be made of 16-gauge aluminum sheet, and are 3 in. deep (the full depth of the chassis). The two main pieces are twelve inches long and $6\frac{1}{2}$ in. long respectively. The 12 in. piece is placed exactly as shown in the diagram, and runs from side to side exactly half-way between the row of I.F. signal stages and the row containing the oscillator-mixer stage (on the left in the under-chassis photograph) and the A.V.C. amplifier and rectifier at the

right-hand end of the row. The $6\frac{1}{2}$ in. piece runs from the front of the chassis to the 12 in. piece, which it joins, $2\frac{1}{2}$ in. from the open end. To the right of this piece are the second R.F. stage, in front, and behind it the oscillator-mixer stage. These two are separated by the 3 in. piece which runs parallel to the 12 in. piece and to the right of the $6\frac{1}{2}$ in. piece. The odd-shaped piece of shielding to the right of this separates the B.F.O. circuit from the A.V.C. amplifier and rectifier tubes. This is most important, for, without it, there would undoubtedly be undesired B.F.O. coupling into the A.V.C. amplifier. If this occurred, we should have the A.V.C. operated by the B.F.O., which is a most undesirable effect.



Detailed view of the mounting of R.F. aerial and oscillator coils. In this photograph, the right-hand edge is the front of the chassis. Along the bottom edge of the picture can be seen the $6\frac{1}{2}$ in. baffle-shield.

To the left of the $6\frac{1}{2}$ in. piece of shielding extend three further pieces, which, together with the $2\frac{1}{2}$ in. overlap of the 12 in. shield, have the job of shielding the aerial, R.F. and oscillator coils from each other. These pieces can not all be seen in the main under-chassis photograph, because this was taken with the cover in place. This cover is shown on the diagram as diagonal shading, and is made to clip firmly over the three $2\frac{1}{2}$ in. pieces which extend to the left of the $6\frac{1}{2}$ in. piece. What cannot be shown in the photograph or the diagram is that the cover extends vertically downwards at its left-hand edge, completely enclosing the shields over which it is placed. In the detailed photograph, which shows the lay-out of the R.F. coils inside their shield compartments, these shields can be clearly seen. The two small holes in the chassis above them are the ones used to fix the cover firmly in place, by means of a small flange.

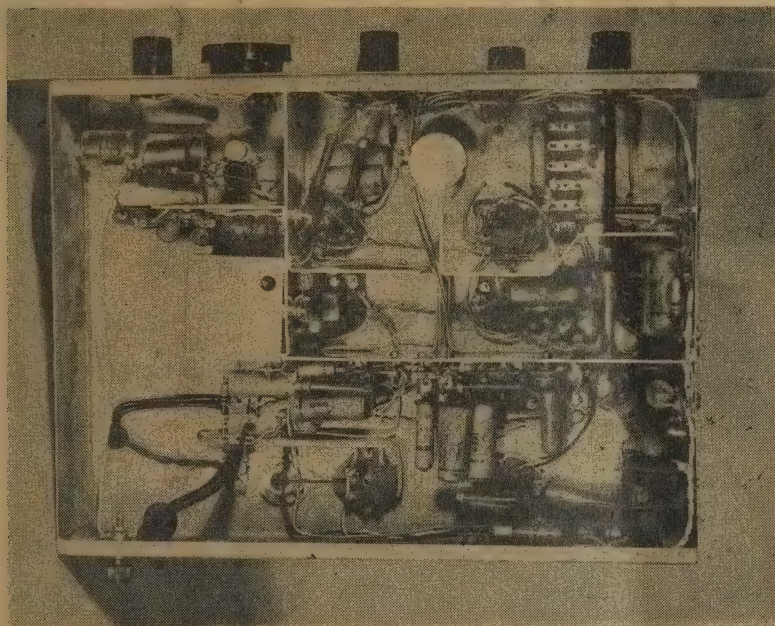
MOUNTING THE R.F. COILS

In this section we make reference to the detailed photograph of the R.F. end of the set. This photograph is not placed the same way up as the general under-chassis view. At the right of the picture can be seen the tone-control potentiometer and the noise-limiter on/off switch. Directly in front of the pot, partly hidden by small components, is the socket for V_1 . To the left of this, mounted horizontally from

the side of the chassis is the 10 mH. choke L_1 , while to the right of the socket is the aerial coil T_1 . This is mounted vertically on the bottom of the chassis. The larger condenser mounted across the valve socket is the 0.1 mfd. A.V.C. bypass condenser for V_1 , namely, C_2 in the circuit. The resistor next to C_2 is R_1 , the grid stopper, whose lead can be seen going off to the grid end of the grid winding on T_1 .

the main under-chassis view will show that the V_2 socket comes directly to the right of the compartment which contains T_2 , and which we have just been discussing.

The next compartment contains T_3 , the second R.F. transformer. In the detailed photograph T_3 cannot be seen, as it is hidden from view by the condenser C_7 , which, with its associated resistor R_9 ,



General underneath view. The portion enlarged in the photograph on the preceding page is the left-hand upper corner in this photo. Here 6½ in. baffle, which runs horizontally at the bottom of the other picture, can be seen at right angles to the front edge of the chassis, with the 2nd R.F. stage and oscillator mixer sockets on the right, and the R.F. compartments to the left.

The other resistor which can be seen parallel with the first, and joining to one of the lugs on L_1 is R_3 , the V_1 cathode resistor. It should be noted that the gang condenser used with this set did not have trimmers mounted on it. For this reason, trimmers have to be provided, though these are not drawn on the circuit diagram. The ones used in the original were 3-30 mmfd. Philips-type trimmers, and all of them, with the exception of the one in the second R.F. stage grid circuit, are mounted directly on the appropriate lug of the coils themselves. The one associated with T_1 can be seen in the detailed photograph, where the hex-nut top can just be discerned beside the aerial coil.

In the next compartment can be seen the first R.F. coil T_2 . This is mounted, not on the chassis, but horizontally, on the 6½ in. baffle-shield, which just appears down the bottom edge of the photograph. It was found inconvenient to mount the trimmer associated with this coil inside the compartment, so it was mounted on the second section of the gang condenser, and can be seen in the top view of the receiver. To the left of T_2 , and mounted on a small piece of resistor-strip (which runs vertically and is mounted on the baffle-shield) are C_3 and R_5 , which decouple the plate circuit of V_1 . Also on this strip are found R_6 and C_4 , which decouple the lead which goes off to the A.V.C. switch, SW₂. Reference to

is mounted on a horizontal piece of terminal strip. T_3 is mounted vertically on the chassis in the same way as T_1 . In its compartment the top of its trimmer condenser can be seen at the right-hand end of C_7 . In the main underneath photograph, it can be seen that a hole has been made in the cover which hides this and the next compartment. This hole is directly above the trimmer, and enables it to be adjusted with the cover in place.

In the last compartment can be seen T_4 , the oscillator coil, which again is mounted horizontally from the 6½ in. baffle-shield. The only other components in this compartment are the oscillator trimmer and the oscillator padder, C_{10} . The latter cannot be seen, being hidden under T_4 . It is mounted in the 6½ in. baffle-shield in the right-hand bottom corner, and its adjusting screw comes out to the right of the 6½ in. baffle, quite close to the V_3 valve socket. It also can be adjusted with the cover in position. The oscillator trimmer is seen in the T_4 compartment with its adjusting head facing left. A hole should be made in the cover so that it may be adjusted after the latter has been put on.

CONSTRUCTING THE BAFFLE-SHIELDING

It is clear that quite a number of leads must pass through the individual baffle-shields. For this reason some care and thought need to be exercised in wiring up the R.F. end of the set. Otherwise, one can easily

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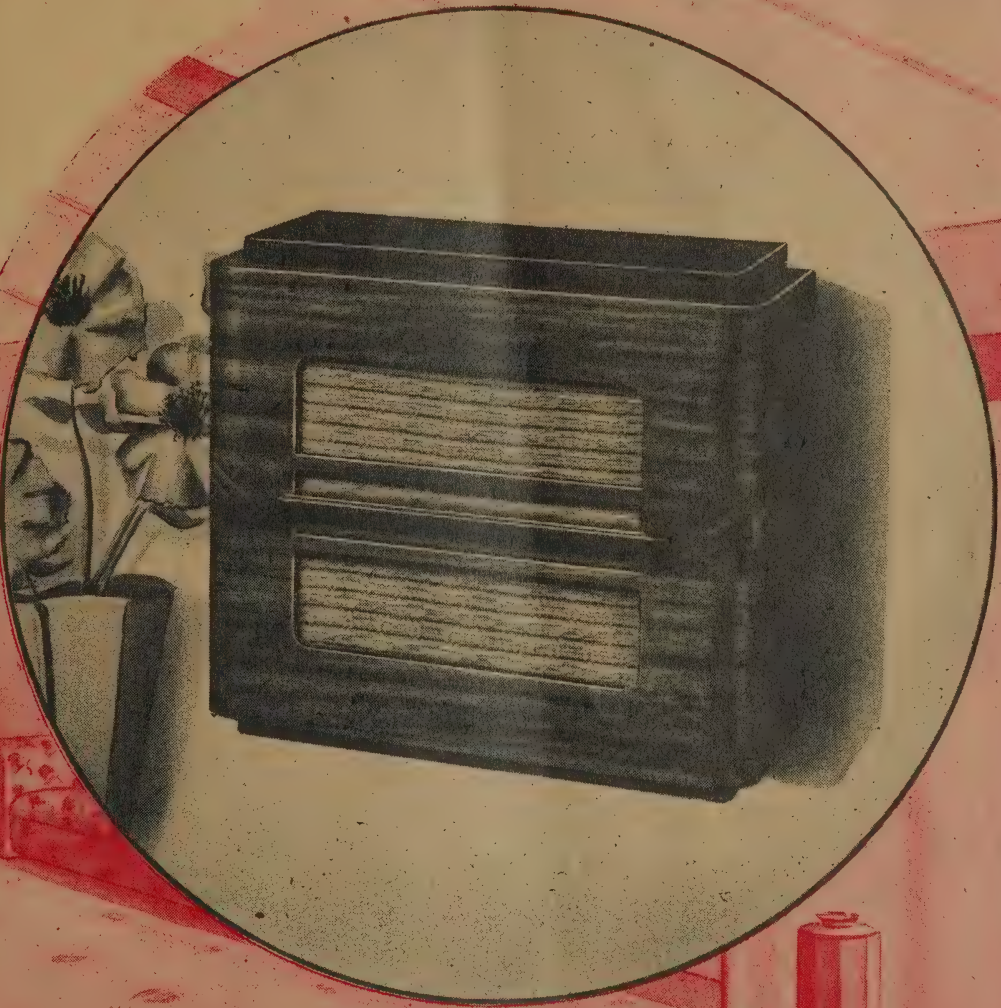


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be in the awkward position of having bolted down the baffle-shields and installed some of the wiring, only to find that this must be unsoldered and the shields removed, so that a few more holes may be bored in the baffles. As an aid to planning the wiring, it may be mentioned that the H.T. leads from the first half of V_1 and the H.T. lead from T_2 each come through the $6\frac{1}{2}$ in. shield, the first on the V_1 side of the 3 in. front shield, and the latter inside the T_2 compartment. In addition, the decoupled A.V.C. lead from T_2 must come through the $6\frac{1}{2}$ in. shield. Through the T_2 compartment also comes the twisted pair carrying 6.3v. for the heater of V_1 . Through the T_3 compartment comes the H.T. lead from T_3 . It will be noted on the main underneath photograph that, opposite each of the V_2 and V_3 sockets and mounted vertically on the $6\frac{1}{2}$ in. shield, is a piece of terminal strip. The one next to V_2 carries one unearthened lug only, which is used as a tie-point for R_8 , the other end of which is soldered directly to the screen pin on the V_2 socket. The two condensers C_5 and C_6 are wired in right at the socket, and can be seen behind it in the photograph. The two resistors crossing these condensers are R_7 and R_{37} , both of which go directly to the appropriate terminal of R_{38} , the manual gain control. R_{40} is seen mounted on the chassis close handy. The terminal strip to which we have just referred is used as a tie-point for H.T. +, and the H.T. leads which come through the T_2 compartment and the T_1 compartment are terminated at this point. The terminal strip next to the V_3 socket, also mounted on the $6\frac{1}{2}$ in. shield, carries three unearthened lugs. One of these is used as an H.T. + tie-point, and the second R.F. H.T. lead comes through the shield and terminates at this point. Also mounted on the strip are R_{12} , the 25k. plate-dropping resistor for the oscillator, and C_{11} , its associated decoupling resistor. C_8 and R_{10} are mounted directly on the V_3 socket pins, while C_9 is terminated on one of the strip lugs, and its connection to T_4 is brought through the $6\frac{1}{2}$ in. shield to this point.

The gang condenser is so mounted that the stator terminal lugs underneath it all come opposite the bottoms of their respective coil compartments. This gives a short lead through the chassis to each tuning condenser, and, incidentally, requires that these holes be bored in the chassis before the condenser is screwed down!

Since a large number of leads must pass through the 12 in. baffle-shield, such as the mixer plate lead to T_5 , the first I.F. transformer, and all the decoupled A.V.C. and cathode leads from the I.F. amplifier, it is a good plan not to bore holes in the shield for them, but to cut "nicks" in the bottom edge of the shield, so that these wires may be put in place before the shield is finally installed. It should be noted that the volume control potentiometer is mounted on the 12 in. shield in a position exactly opposite the hole allowed for the extension shaft in the front panel. The peculiar shape of the B.F.O. baffle-shield allows the full length of the volume control pot.'s shaft to be used before the flexible coupling is attached, thus reducing the length of the extension shaft. The latter, of course, passes through the B.F.O. shield, which is not used as a bearing for the extension shaft.

THE I.F. WIRING

Many of the components in the I.F. amplifier are mounted on two terminal strips which themselves mount horizontally on the I.F. side of the 12 in. baffle. These strips cannot be seen very well in the photograph, as they are obscured by the components mounted on them. However, each has five unearthened lugs and is mounted with its centre above and opposite its appropriate I.F. tube socket. With regard to the 6SK7 first I.F. stage, this has C_{15} mounted across the socket in the manner recommended for single-ended tubes by the manufacturers, and acts as a shield between plate and grid pins. On the strip above the socket are mounted R_{18} , R_{17} , and R_{16} only.

The unbypassed portion, R_{15} , of V_4 's cathode resistance is connected directly between the cathode pin on the valve socket and the appropriate end of R_{16} , on the strip. The bypass condensers C_{13} , C_{14} , and C_{15} are all earthed to the same point on the chassis, and their "high" ends taken by the shortest possible route to the points which they bypass. Since the I.F. transformers used had flexible leads and not rigid terminal wires, these leads were brought through $\frac{1}{8}$ in. holes in the chassis. The "cold" ends of the windings were terminated on small single-lug terminal strips also mounted on the chassis as near as possible to the points at which these leads come through. This ensures, when the bypass condensers and decoupling resistors are wired to the strips, that only about $\frac{1}{8}$ in. of unbypassed lead comes through the chassis, and aids materially in obtaining the stable operation that is essential with a circuit of this kind. The wiring of V_5 is performed in a similar way to that of V_4 . If, as was done in the original, all points that need decoupling are bypassed right at the valve socket or right where the lead comes through the chassis, the decoupled lead may then be taken anywhere in the set without likelihood of causing undesired coupling and oscillation. Thus, the individual tubes' A.V.C. and decoupled cathode and H.T. leads are all run through a hole in the 12 in. baffle-shield, and thence right across the chassis to the A.V.C. on/off switch and manual gain control potentiometer without any danger of instability.

Points in connection with the wiring of the second detector and noise limiter tube are: (1) A piece of terminal strip is mounted vertically on the side of the chassis directly over the socket of V_6 . On this strip are mounted C_{22} , C_{24} , R_{25} , R_{24} , R_{27} , and C_{22} . The lead from C_{22} to the noise limiter on/off switch is then taken right round the right-hand side of the chassis after passing through the 12 in. baffle and along the front of the chassis to the switch. The return lead follows the same way back and terminates on the valve socket pin for the second diode plate of V_6 . This is another example of a lead which has been decoupled to both audio and R.F., and which can therefore be run anywhere without trouble from instability. (2) The lead from the moving arm of R_{28} , the audio volume control potentiometer, though very long on the circuit diagram, is non-existent in practice, since C_{35} mounts directly between this point and the grid pin of V_{10} , which is only a couple of inches away.

(To be continued.)

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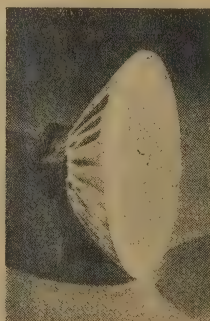
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FREQUENCY MEASUREMENT

PART IX

In describing the calibration of the broadcast band of a receiver, the method detailed was that of using broadcast stations as standard frequencies, and the frequency standard merely as a check. For the sake of completeness, we will now describe how the frequency standard may be used on its 100 kc/sec. series, instead of broadcast stations, which are not always in operation in these troublous times.

The standard, as now constructed, will give signals spaced every 100 kc/sec. and so may be used to calibrate the broadcast band of a receiver as long as one of the series can be identified positively. Here, again, the auxiliary oscillator finds a useful role as a check.

The first step is to turn on the standard, using the 1000 kc/sec. series only. In this case, the only signal which will be audible on the band will be the fundamental 1000 kc/sec. from the oscillator. After the latter has been checked against WWV in the usual way, the signal is accurately re-tuned on the receiver, and the dial setting marked.

Now the 100 kc/sec. series is turned on. This will bring up signals right across the band, so that the procedure now is to tune the set towards the high frequency end of the band, starting from the 1000 kc/sec. mark. The first signal encountered will be 1100 kc/sec., which can be marked, and then successive 100 kc/sec. points are marked in until the end of the band is reached. The tuning is now returned to 1000 kc/sec., and moved slowly in the low frequency direction. The first signal received will be 900 kc/sec., the next 800, and so on, the last to be on the dial being 600 kc/sec., if the receiver is properly aligned.

CHECKING WITH THE AUXILIARY OSCILLATOR

In this case there is no ambiguity—or should not be—unless the receiver has a very poor image ratio, in which case all signals received can be marked.

There can be no ambiguity with the 1000 kc/sec. point, since the image response is not in the tuning-range of the receiver (assuming high-side oscillator working and a 465 kc/sec. I.F.). However, image responses of the 100 kc/sec. series may be identified by one of the methods described in the last instalment of this series. If the image response problem does not exist, or when it has been settled, there should be very little doubt as to the accuracy of the calibration. However, the auxiliary oscillator can again be brought into action as a check. The receiver is tuned to one of the 100 kc/sec. marks, as previously identified, and the auxiliary oscillator is loosely coupled to the aerial lead. The oscillator is now tuned slowly about the nominal frequency to which the receiver is tuned until the signal is picked up in the receiver. The oscillator is now accurately tuned to the receiver, and the frequency is read from the oscillator calibration. Any calibration error will now show up as a non-correspondence between the nominal receiver frequency and the nominal oscillator frequency.

CALIBRATING OR CHECKING OSCILLATORS

So much for the use of the standard to calibrate a receiver. All our description has centred round superhet. receivers, since these represent the most complex cases which will be met, owing to the diffi-

culties with images. The same procedures exactly can be used with "straight" or regenerative receivers, but are simplified to the extent that no image responses can occur with these types of receiver.

Perhaps the greatest use for the standard will be in the accurate calibration of oscillators, so that we will now go on to say something on this subject.

There are several procedures which may be used in calibrating an oscillator with the frequency standard, but the exact method used in any one case will depend on several factors—whether or not the oscillator under calibration is of fixed frequency, the frequency or frequency range of the oscillator, to mention the two most important.

For example, if a "fixed frequency" oscillator is to be checked, the procedure will depend on whether or not the nominal frequency is a multiple or sub-multiple of one of the standard frequencies. If it is a multiple of one of the 1000 kc/sec. series, all that is required for checking is a receiver which will tune to the oscillator frequency or one of its harmonics. If it is a sub-multiple, say, 500 kc/sec., the procedure can be exactly the same, save that in this case a harmonic of the oscillator, say, 1000 kc/sec., must be used as the checking frequency. Again, if accurate measurement is required, means must be provided for measuring a beat frequency which will usually be within the audio range, whereas, if a check only is required, all that has to be determined is whether the observed beat frequency is lower than a particular audio frequency.

GENERAL PRINCIPLE

The general principle used in the calibration of a signal source rather than just a receiver, is the principle of beats, certain applications of which have already been described in this series. However, the cases already used as illustrations of the method were very simple ones, involving only the use of the single standard frequencies emitted by WWV. Now that we have a secondary frequency standard available, a great deal more becomes possible, and the extensions of the beat frequency method of calibration is worth going into in several cases that are commonly encountered.

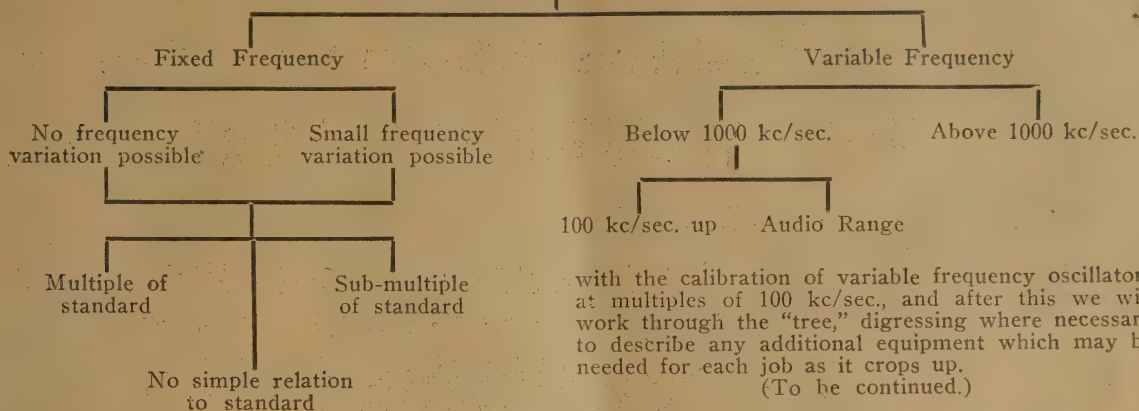
The following "tree" shows the various types of oscillator most likely to be encountered, and indicates the number of different methods which must be used if any oscillator is to be calibrated, irrespective of type. Although the tree shows quite a formidable number of arrangements, basic methods in some cases are identical, and the different types are handled each by a comparatively slight variation on the main theme. For example, the only difference between the methods used for a fixed frequency oscillator and one in which a slight variation is permissible about the nominal frequency is that in the former case it is considerably more troublesome to carry out the usual determination of whether the oscillator is too high or too low with respect to the nominal frequency. Again, the method of measuring frequencies which are multiples of a standard frequency, as against those which are submultiples of the standard is merely a question of which source is used at its fundamental frequency—the standard or the oscillator under calibration. It will be noted that on the "tree" no separate mention has been made of the measure-

ment of oscillators at very high to super-high frequencies. This is because, although such measurements are necessarily more complicated than lower

frequency measurements, the difference is one of degree rather than kind.

In the next instalment of this series, we will begin

OSCILLATORS



with the calibration of variable frequency oscillators at multiples of 100 kc/sec., and after this we will work through the "tree," digressing where necessary to describe any additional equipment which may be needed for each job as it crops up.
(To be continued.)

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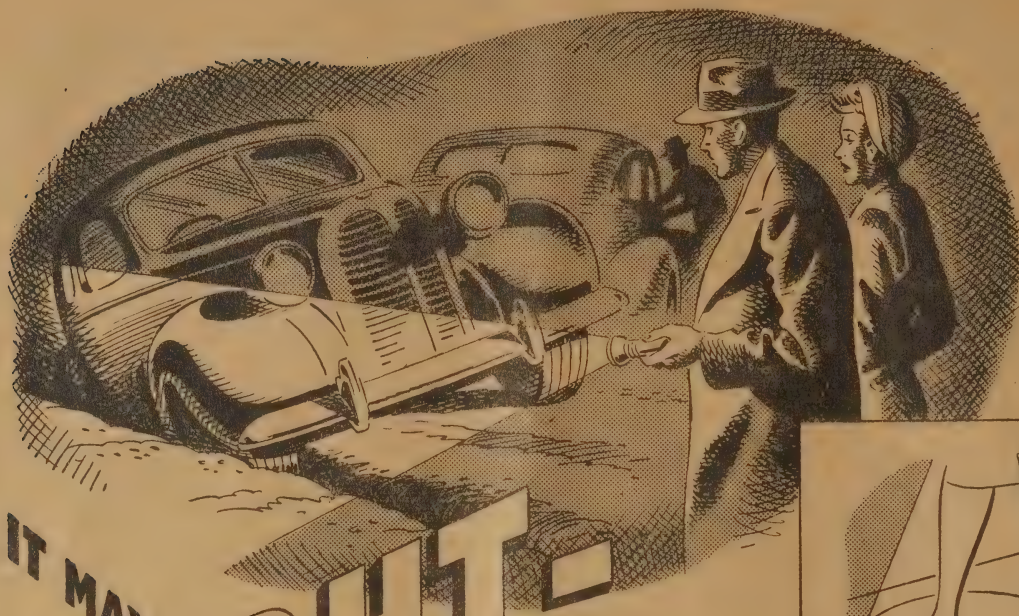


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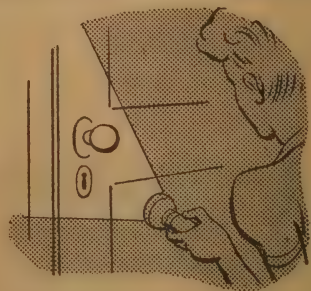
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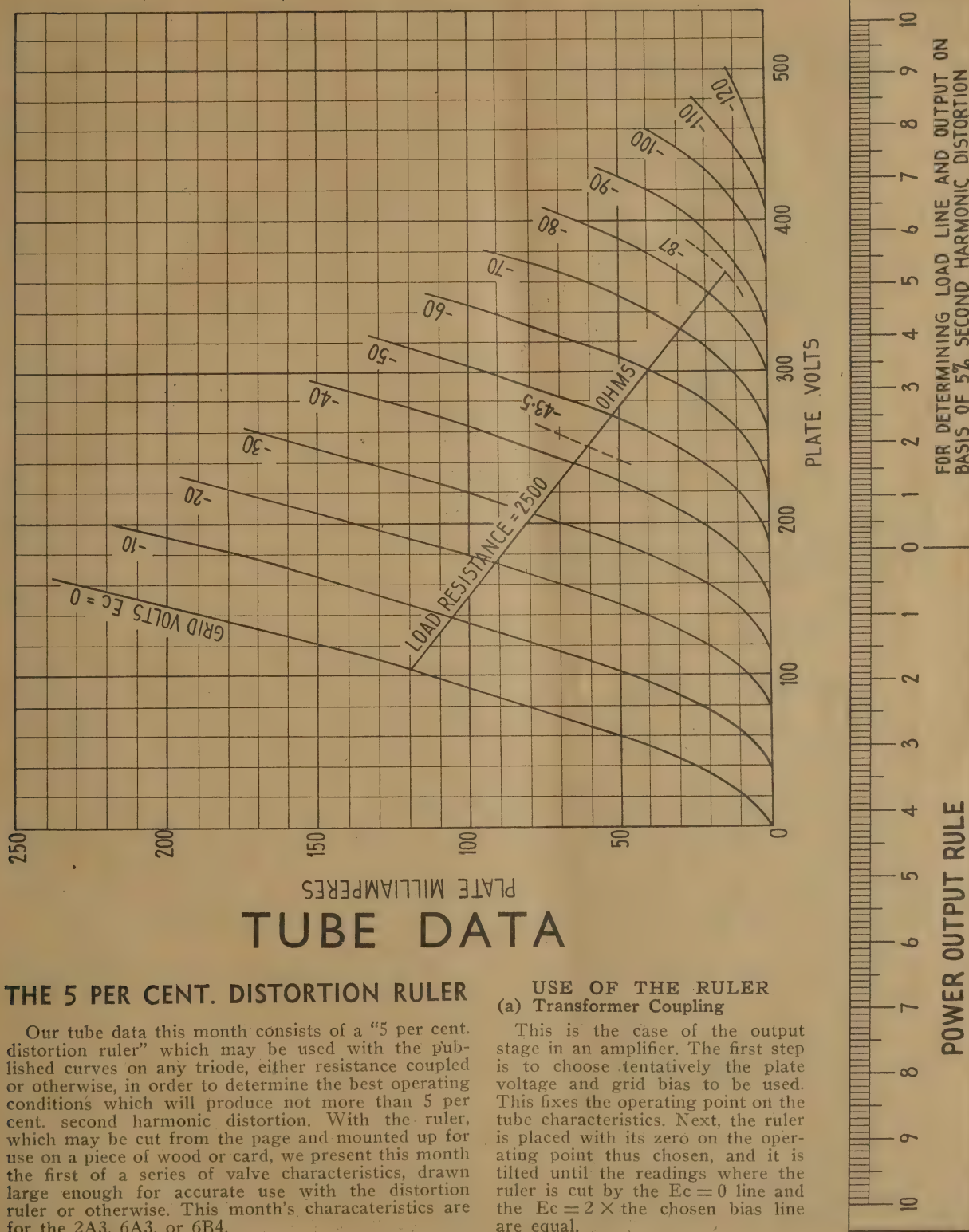
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THE 5 PER CENT. DISTORTION RULER

Our tube data this month consists of a "5 per cent. distortion ruler" which may be used with the published curves on any triode, either resistance coupled or otherwise, in order to determine the best operating conditions which will produce not more than 5 per cent. second harmonic distortion. With the ruler, which may be cut from the page and mounted up for use on a piece of wood or card, we present this month the first of a series of valve characteristics, drawn large enough for accurate use with the distortion ruler or otherwise. This month's characteristics are for the 2A3, 6A3, or 6B4.

USE OF THE RULER

(a) Transformer Coupling

This is the case of the output stage in an amplifier. The first step is to choose tentatively the plate voltage and grid bias to be used. This fixes the operating point on the tube characteristics. Next, the ruler is placed with its zero on the operating point thus chosen, and it is tilted until the readings where the ruler is cut by the $E_c = 0$ line and the $E_c = 2 \times$ the chosen bias line are equal.

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With the rule in this position, it represents a load resistance which will give not more than 5 per cent. second harmonic distortion, with the plate volts and grid bias chosen. On the 2A3 curves we have shown this position of the ruler for a plate voltage of 250, a grid bias of 43.5v., and a load resistance of 2500 ohms.

FINDING THE LOAD RESISTANCE

When the correct position of the ruler has been found the load resistance represented by it may be found thus:

- (1) Draw on the curves a line representing the chosen position of the ruler, but extending out to both axes of the graph.
- (2) Read off the values on the plate current and plate voltage scales, at the point where this line cuts them. Let these readings be E and I respectively.
- (3) Work out the resistance in ohms from the formula

$$R = \frac{1000 E}{I} \text{ ohms.}$$

The use of the rule does not limit one to a distortion level of 5 per cent. Thus, if the ruler is pivoted about the operating point so that it becomes more nearly horizontal, it will be found that the intercept between the operating point and the $E_c = 0$ line now reads less than the intercept between the operating point and the curve for twice the bias. This means that the distortion is less than 5 per cent., but this is achieved at the expense of power output which decreases also. The rule for getting the required power output with minimum distortion is to tilt the ruler until the ratio of readings on the two scales is as great as possible without reducing the power output below the figure required. The power output can be estimated in any given case from the formula

$$(E_{\max} - E_{\min})(I_{\max} - I_{\min}) \div 8$$

where E_{\max} and I_{\min} are the voltage and current represented by the lower end of the load line (where it cuts the curve for twice the operating bias), and E_{\min} and I_{\max} are the figures for the upper end of the load line, where it cuts the $E_c = 0$ curve. In this formula E and I should be expressed in volts and amperes, not milliamps.

(b) Resistance Coupling

Here the plate supply voltage is known, or assumed, and it is required to choose the load resistance and grid bias that will give maximum gain with the second harmonic output limited to 5 per cent. at maximum signal.

The first step is to decide what plate supply voltage can be used, remembering that the rule is the higher the better.

Next, the load resistor is chosen. This should be five times the plate resistance of the tube or greater, and will give increased voltage gain the larger it is. Once a tentative value has been fixed, a small sum must be worked out according to

$$I = \frac{1000 E}{R} \text{ ma.}$$

where R is the value of the chosen load resistor in ohms, and E the chosen plate supply voltage.

When this sum has been worked out, a straight line is drawn on the valve curves from E on the plate volts axis, to the worked out value of I on the plate current axis. This line represents the chosen plate load resistor, and the operating point must be somewhere along it.

The final step is to take the distortion ruler and slide it along the load line thus drawn until the intercept from zero to the $E_c = 0$ curve gives a reading equal to the intercept between zero to where the ruler cuts the curve for twice the grid bias represented by the position of the zero on the curves.

For example, supposing it is desired to use resistance coupling out of a 2A3 (since we have the curves here) with a plate supply voltage of 500v. and a load resistor of 5000 ohms. The load line would thus be drawn from 500 on the plate volts axis to 100 on the plate milliamps axis. Now, sliding the ruler upwards along this line, it is found that with the zero half way between the -50v. curve and the -60v. curve (i.e., $E_c = 55v.$), the ruler reads 5 at the $E_c = 0$ curve, and 5 on the $E_c = 110v.$ curve.

Now these points where the load line crosses the $E_c = 0$ and $E_c = 110$ curves correspond to plate voltages of 80v. and 422v. respectively. Thus the peak-to-peak output voltage would be 342v., and the peak output voltage 171v., with 5 per cent. distortion. The bias voltage would be -55v., and the D.C. plate current 45 ma., with an actual steady plate voltage of 280v. The voltage gain would be $171 \div 55 = 3.1$ times.

The above is not, perhaps, a very practical example, but serves to indicate the method. If, for example, the 2A3 in the above case was required to give a peak output voltage of 100, it could be relied upon to do so with considerably less than 5 per cent. second harmonic distortion.

With resistance coupled triode amplifiers the distortion will in general be less the higher the load resistor, and so will the output voltage for a given distortion.

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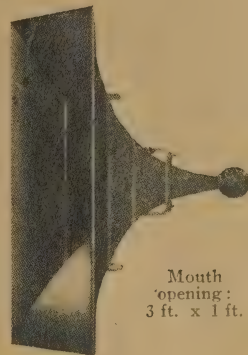
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THE RADEL DUAL-WAVE 6

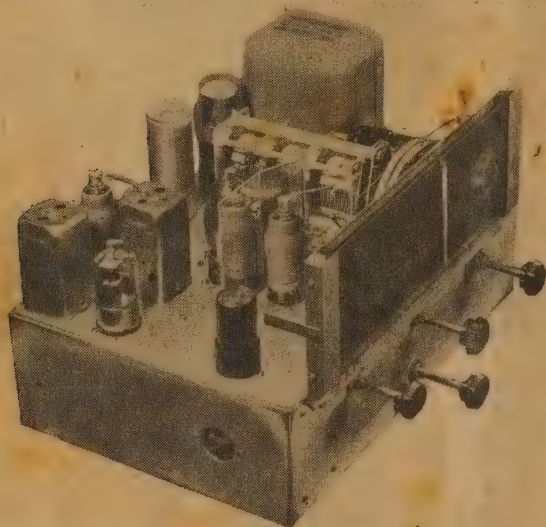
This receiver is built round a commercial dual-wave coil unit, and gives excellent results on both broadcast and shortwave bands. For the first time the infinite-impedance mixer circuit has been used in a receiver designed for the home constructor.

For some time now kits have been available consisting of matched coils, gang-condensers, and dial specially designed for the home constructor who wishes to turn out a really worth-while dual or triple-wave receiver. This set has been designed round one of these units in such a way as to make the most of its performance. The new infinite-impedance mixer has been used in order to achieve a better-than-average signal-to-noise ratio, and this, combined with a good-quality audio amplifier system and a

compensates in part for the fact that a certain amount of gain has been deliberately sacrificed by using a triode mixer. However, constructors need have no fear that the sensitivity of the receiver is too low to allow good weak-signal performance. In fact, the set's performance in this respect is much better than that of most receivers which may have a higher overall gain, but a poorer signal-to-noise ratio. The I.F. stage is quite conventional, and uses iron-cored transformers. Again, these are essential in order to keep up the overall sensitivity.

The functions of first audio stage, second detector, and A.V.C. rectifier are combined in a 6Q7-GT, V_4 . Here, again, the circuit is quite standard, although slightly more complex than some second detector A.V.C. circuits. Particular note should be made of the fact that R_{13} is the detector diode load resistor and volume control potentiometer at the same time, and is preceded by the filter C_{13} . R_{12} , C_{14} , which ensures that a minimum of R.F. voltage is passed on to the audio amplifier. The use of the diode load resistor as the audio volume control ensures that loading on the diode circuit is a minimum, and allows the detector to handle greater modulation percentage without distortion.

The output stage, V_5 , is a 6V6, and provides $4\frac{1}{2}$ watts of audio output. A somewhat novel stepped tone control has been used here, which, like another circuit published in "Radio and Electronics," gives a boosting effect to the bass while leaving the high audio frequencies unattenuated. This part of the circuit works as follows: The output voltage of V_5 appears across the network comprising C_{19} , R_{24} , and R_{23} , which latter is in three sections. Now, the grid circuit of V_5 consists of R_{20} in series with R_{21} , and the junction of these two resistors is taken to the common point on the tone control switch. R_{21} is connected by the switch across varying proportions of R_{23} , so that as the switch arm moves towards R_{21} , a greater proportion of output voltage is fed back to the input of V_5 . The value of R_{24} in series with R_{23} is 100,000 ohms, and C_{19} is 0.02 mfd. Since R_{19} is so small, a greater voltage appears across R_{23} at middle and high frequencies than at low frequencies. Thus, wherever the moving arm of the switch may be, there is always less feedback at low frequencies than anywhere else in the audio spectrum. Thus, the output stage has more gain at low than at high frequencies, and bass-boost can be said to take place. However, on account of the shunting effect of R_{21} on R_{23} (which has a greater effect the higher the tapping point), the total resistance from C_{19} to ground decreases as the tone switch is moved toward R_{21} . Thus, the inequality between the feedback factors at low and high frequencies increases as the tapping position increases, with the result that the degree of bass-boost increases also. At the same time, this shunting effect contrives to keep the overall



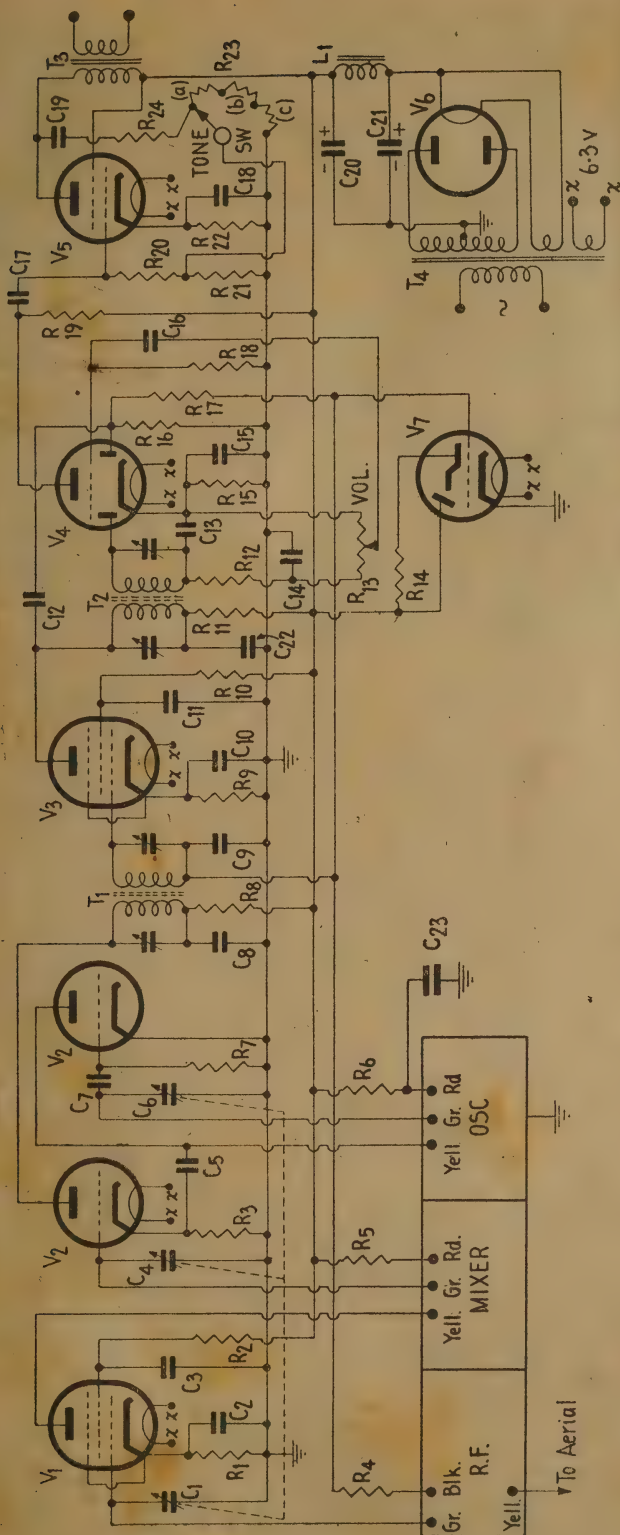
General view of the Dual-wave 6. Note the aluminium baffle-shield between the EF39 R.F. stage and the 6F8-G oscillator-mixer.

magic-eye tuning indicator, provides the constructor with a set which compares more than favourably in performance with commercial sets using a similar tube line-up. The use of the infinite-impedance mixer gives a very definite gain in shortwave performance, particularly from the points of view of quiet operation and stability of tuning adjustment.

A tapped switch type of tone control circuit has been used which works on the variable negative feedback principle.

THE CIRCUIT

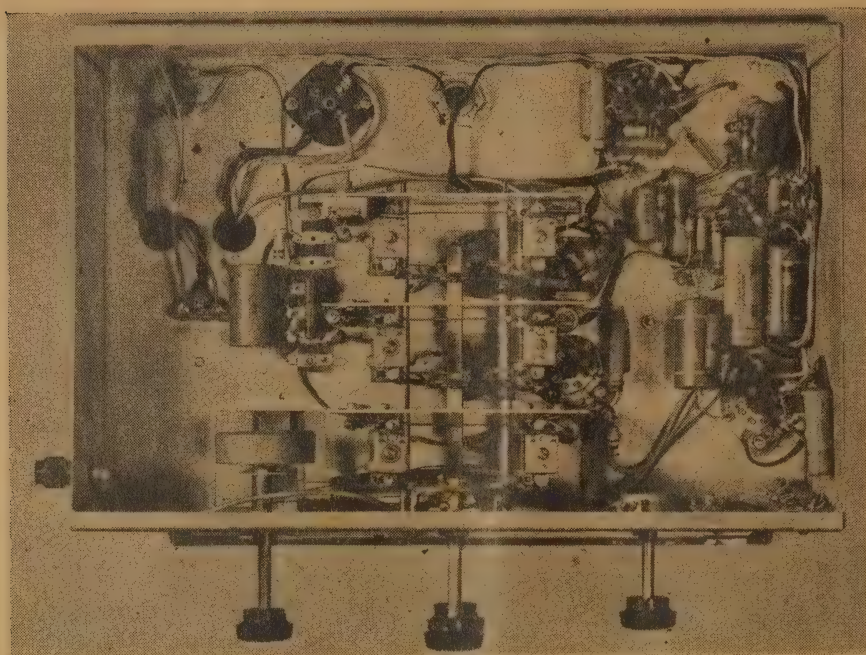
V_1 is an EF39, used as an R.F. amplifier. V_2 is the infinite-impedance mixer and oscillator, and uses a 6F8-G. The latter tube is electrically identical with the 6SN7-GT, except for slight changes in the inter-electrode capacities, and has the advantage that one triode has its grid brought out to a top-cap, so that normal lay-out practice may be followed for the mixer stage in the receiver. The I.F. amplifier has a single stage, also using an EF39. This tube has a higher mutual conductance, and therefore a higher gain than other R.F. pentodes normally available, and its use in the R.F. and I.F. stages in this receiver



COMPONENT LIST

$R_1 = 350$ ohms 1w.
 $R_2, R_3, R_6, R_{10} = 100k. \frac{1}{2}w.$
 $R_4, R_{12}, R_{21} = 50k. \frac{1}{2}w.$
 $R_5 = 4k. \frac{1}{2}w.$
 $R_7, R_{24} = 25k. \frac{1}{2}w.$
 $R_{8, 11} = 2k. \frac{1}{2}w.$
 $R_9 = 350$ ohms 1w.
 $R_{13} = 500k. pot.$
 $R_{14}, R_{16}, R_{17} = 1$ meg. $\frac{1}{2}w.$
 $R_{15} = 3k. \frac{1}{2}w.$
 $R_{18} = 500k. \frac{1}{2}w.$
 $R_{10} = 250k. \frac{1}{2}w.$
 $R_{22} = 250$ ohms 1w.
 R_{23} (a), (b), (c) = each $25k. \frac{1}{2}w.$
 C_1, C_4, C_6 = Three-gang condenser (see text).
 $C_2, C_8, C_{10}, C_{11}, C_{22} = 0.05$ mfd. 600v. paper.
 $C_3, C_7, C_{13}, C_{14} = 100$ mmfd. mica.

$C_9 = 0.1$ mfd. 600v. paper.
 $C_{12} = 50$ mmfd. mica.
 $C_{15}, C_{18} = 25$ mfd. 25v. electro.
 $C_{17} = 0.25$ mfd. 600v. paper.
 $C_{19} = 0.02$ mfd. 600v. paper.
 $C_{20} + C_{21} = dual 10$ mfd. 450v. electro.
 $C_{23} = 8$ mfd. 450v. electro.
 $V_1, V_3 = 6F8-G.$
 $V_2 = 6Q7-GT.$
 $V_4 = 6V6.$
 $V_5 = 80.$
 $V_6 = 6U5$ or $6G5.$
 $T_1, T_2 = 465$ kc/sec. I.F. transformers.
 T_3 = Speaker transformer, 5000 ohms to v.c.
 T_4 = Power transformer, 385-0-385v. 80 ma., 6.3v., 5v.
 $L_1 = 1500$ -ohm speaker field.



Left: The under-chassis arrangement. The controls, left to right, are tuning, tone control switch and volume. The wave change switch shaft is directly beneath the tone control shaft. The tube at the right front of the chassis is the 6V6 output stage. The sockets for the R.F. and osc.-mixer stages may be seen in the two back compartments of the coil unit. Directly behind the 6V6 socket is that of the 6Q7-GT, while the ones at the back of the chassis are the I.F. amplifier, with the rectifier at the left near the power transformer leads.

Below: Chassis diagram. Note the position of the baffle-shield between the R.F. and mixer stage sockets.

feedback approximately constant for all taps except the lowest, on which there is no feedback at all.

The circuits used in the power supply and the magic-eye tuning indicator are quite standard, and require no special comment.

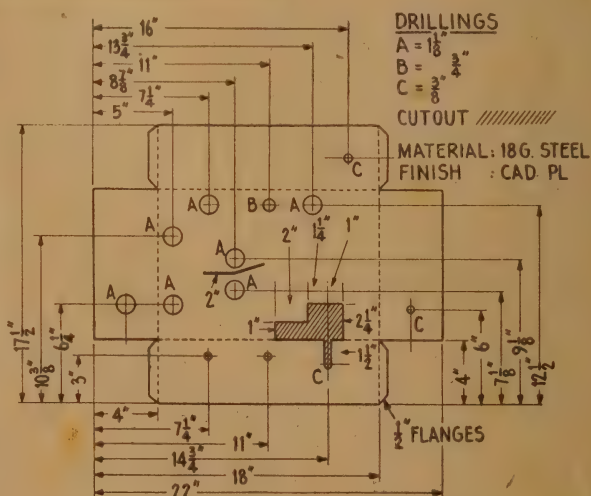
MODIFICATION TO COIL UNIT

Our circuit diagram shows the colour-coding of the leads from the coil unit. It will be noted that in the section marked "Mixer" no black lead has been shown. This would appear to be an omission, since examination of the unit itself will show that a black lead exists. This is the one which, corresponding to the black lead from the R.F. stage section of the coil unit, would normally be connected through a decoupling resistor to the A.V.C. line. However, it is not possible to apply A.V.C. to the infinite-impedance mixer, whose grid circuit must be directly earthed. On looking inside the unit, it will be found that the black lead is bypassed to earth by a condenser. This condenser may be removed, and the point to which it is tied must be earthed to the aluminium shield of the compartment, thus completing both A.C. and D.C. paths for the grid circuit of the mixer tube. Apart from this slight change, no alteration in the coil unit is necessary to make it suitable for the infinite-impedance mixer circuit.

It will be noted that no bypass condensers have been shown across the A.V.C. and plate decoupling resistors R_4 and R_5 . The reason for this is that these condensers are included in the construction of the unit itself.

PURCHASING OF PARTS

The only point to watch in purchasing parts for this unit is that the coil unit, gang condenser, and dial must "belong" to each other. If they do not, proper tracking throughout the bands will not be obtained, and neither will the actual tuning frequencies of the set correspond to the calibration of the dial. No advice as to makes of parts can be



given here, of course, but any matched kit will give satisfactory results.

Incidentally, there is no necessity to make this set a dual-wave one if a triple-wave version is preferred, since the manufacturers of the coil units and dials that are available also turn out triple-wave coil units and dials. The triple-wave units have no extra connections to them, compared with the dual-wave one, so that, if desired, one of these may be substituted in our circuit with no further complication.

PUTTING THE SET INTO OPERATION

When the wiring has been completed, it is well to give it a thorough check over, to ensure that nothing has been left out, and that no mistakes have been made. When one is satisfied that all is correct, the

(Continued on page 48.)

QUESTIONS and ANSWERS

J.H., Wanganui, writes:

"I wonder if you have on hand a circuit for an amplifier using push-pull 45's driven by a 6SJ7 followed by a 6J7-GT or 6J5-G. I have the valves but no circuit. I am using the power transformer and I.F. choke out of an old 'Majestic' set which had P.P. 45's in the output stage, and also the 10 in. speaker."

In the April, 1946, issue of "Radio and Electronics" is described a push-pull 6A3 amplifier, the circuit of which will suit J.H.'s purpose admirably, provided that the 6.3v. filament winding for the 6A3's is altered to 2.5v. for the 45's.

The bias resistor R_{12} can remain at its previous value of 750 ohms and the 6C5 can be replaced by a 6J5 without circuit alteration, and without any effect on the performance.

The power supply can remain as in the original amplifier, if the speaker field winding is to be used as the second choke. If the speaker is a permanent magnet one, L_1 can be replaced by a 750 ohm 10 watt wire-wound resistor.

The amplifier with 45's instead of 6A3's will give just as good quality as the original, and a power output of about 5 watts, owing to the smaller output tubes used.

Further to his question which was answered in last month's column, R.T.W. writes:—

"It is usual when using a $\lambda/4$ stub as a matching transformer to tap the untuned feeders on to the stub some distance from its lower end, which may or may not be shorted according to stub length. Why, then, in this case, are the feeders connected directly to the lower end of the stub? It seems to me that the stub, being in effect a $\lambda/2$ section folded in two, would be shorted at the lower (low impedance) end. Do the feeders in effect act as a shorting bar? If so, why do they not act as such in all cases?

Perhaps the answer is related to a similar case which has puzzled me for some time. In the case of a delta-matching transformer to connect, say,

a 600 line to the centre of a $\lambda/2$ antenna, the antenna is not cut. Yet, in the case of use of "twisted pair" feeders, with a little fanning at the top, the antenna is cut and an insulator inserted. Would you be good enough to tell me why?

I wonder whether the 1-8 in. perspex will be of sufficient strength at the centre of 250 ft. of 7/.044 hard drawn copper wire?"

The point about the matching transformer specified in last month's answer to R.T.W.'s original query is that this is not the same thing as a shorted or open stub, on some point along which the feeders are tapped. Here, the "transformer" is $\lambda/4$ long, and has the property that if any impedance Z_1 is attached to one end, the impedance Z_2 reflected at the other end is given by the formula—

$$Z_2 = \frac{Z_c^2}{Z_1}$$

where Z_c is the characteristic impedance of the piece of line making up the transformer. This follows from the more usual equation—

$$Z_c = \sqrt{Z_1 Z_2}$$

Thus, if a given impedance is attached to one end of the transformer, the impedance at the other end can be varied by altering the spacing of the transformer wires, which, in turn, alters Z_c .

With a shorted $\lambda/4$ stub, to the open end of which the aerial is connected, the impedance varies along the stub from zero (at the shorting bar) to the value of the aerial impedance at the other end. With the stub, the characteristic impedance of the line from which it is made has practically no effect on impedance found at any particular point along the line.

With regard to the second query, the impedance at the centre of an aerial which is cut at the centre is in the region of 72 ohms. If the aerial is **not** cut at the centre, as when delta-matching is used, the impedance across a few inches of the aerial, about the centre point, would be very low—only a few ohms. Thus, when making a delta-matched aerial, the wires from the feeders are fanned out to tap on to two points on the aerial across which the impedance equals that of the **fanned out** portion of the feeder. This value will not be 600 ohms, but considerably higher, the fanned portion acting as an impedance

(Continued on page 48.)

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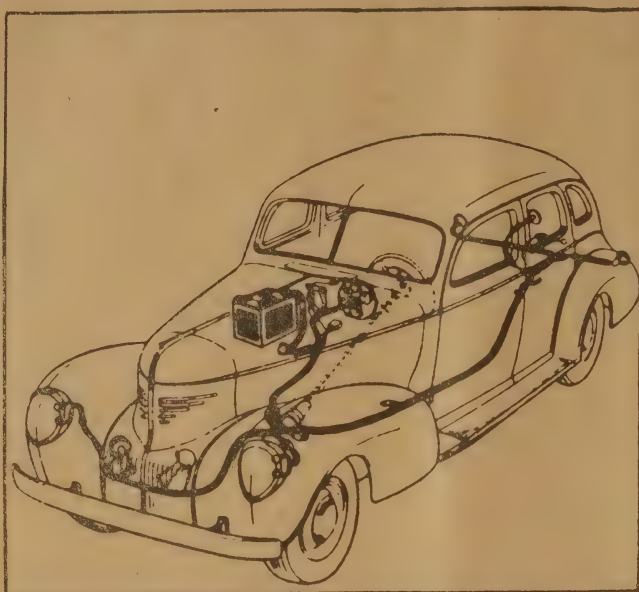
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OUR GOSSIP COLUMN

We mentioned last month that Herb Dixon, in association with Jack Maddever, and trading as "Radio Sound and Service," Wellington, had taken over the P.A. and radio service departments of Green and Cooper Ltd.

Commencing radio business in 1927 with Wally Green, they came into the radio limelight through their broadcast station 2ZR, and later in 1931 they gave valuable assistance to the Government in maintaining radio communication during the Napier earthquake.

Herb later left Wally Green, and after a cruise of the South Seas lasting about a year, he returned to New Zealand, taking up an appointment with Hope Gibbons for a short time before joining Charles Begg and Co., Ltd.

At the outbreak of war, Herb joined the Navy, shortly afterwards being posted as Staff Officer to Admiral Sir Geoffrey Layton, C. in C. China, after which he was sent to Hong Kong in control of Naval radio construction in the Far East.

At the outbreak of war with the Japanese, the Naval Transmitter at Stonecutters Island was destroyed, and with the aid of equipment already manufactured, Herb took over and maintained communications.

After the surrender, he was taken prisoner, and prison life began with the immediate problem of setting up radio communication from the camp.

A transmitter was improvised in one camp, and receivers in each of three camps. Two receivers were modified commercial sets, but in the case of the third receiver, with the exception of valves, no components were available for its construction. Nevertheless, with typical British determination, Herb and his assistants began the construction of a receiver from materials available from the camp. The filter condensers were made from the metal foil in cigarette packets, and impregnated in candle grease encased in metal cut from kerosene tins.

Earphones were constructed from Red Cross sugar and cheese tins and diaphragms from the thin metal seals of cigarette tins. The pole pieces were a problem, but eventually transformer laminations were "obtained" by parties working outside the camp, and these were used for the pole pieces. Working parties also "obtained" old wire for coil winding, and the finished coils consisted of many different gauges of wire connected together. Lead pencils were utilised for resistors, and the chassis was an old copper sterilizer. By a great deal of "by guess and by God" the receiver functioned satisfactorily on its first trial.

The secrecy of the radio sets eventually broke down and the Jap Gendarmerie searched the Camp with the result that Herb and three senior officers were taken to Gendarmerie Headquarters, where they were under constant interrogation for three months.

On 22nd September, 1943, they were removed to cells in Stanley Gaols to await execution. Later, they were given a Jap "Court Martial" and sentenced to 15 years confinement. Two years of this sentence were served, a great deal of which was in solitary confinement.

They were at last relieved by Rear Admiral Harcourt, R.N., and Herb returned to New Zealand via Australia.

For his work in Japanese prison camps Herb was awarded the M.B.E.

To Ian Ferguson of Huntly go our congratulations for his fine new shop, which is much larger than his previous premises. Ian can now display electrical and radio goods to the fullest advantage.

"Command Service" is the encouraging title adopted by two Air Force "types," A. G. Stanley and E. H. Brown, for their new radio and electrical enterprise in Hamilton. "Take-off" was scheduled for April 3.

Ralph Slade of Philips Electrical Industries has been in Australia for three weeks on a general business tour.

DX LISTENERS GATHER IN WANGANUI

Despite Bob Semple's prayers for rain and the cessation of normal rail transport, DX listeners from the branches of the N.Z. DX Radio Association Incorporated gathered in Wanganui for their annual Easter Conference. Delegates and visitors represented the Association's membership of 2,082, delegates being from Auckland, Wanganui, Wellington, Canterbury and Dunedin, plus Headquarters (Wellington) and Magazines Committee (Wellington).

The visitors were welcomed by the President of the Wanganui Branch, Mr. R. Neale, and Secretary H. Bagley. A very comprehensive business and social programme, extending over the Easter period, was organised by the Wanganui Branch, resulting in the 1947 Conference being the most photographed event in the Club's history.

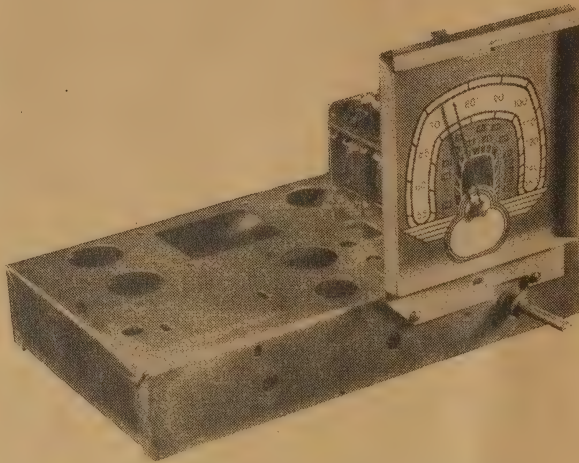
Those present included: Messrs. B. Neale and H. Bagley of Wanganui who were the hosts; Messrs. Case and Clark of Auckland, Featenby and Irvine of Wellington, C. Brown of Headquarters, R. Free of "Tune-In," Harbett and Reynolds of Canterbury, and A. Greenway of Dunedin as official representatives. Others present included Messrs. M. Kelly, Treasurer; E. Watson, Liaison Officer, Christchurch; B. Beauchamp, President, and J. Saunders, Secretary of Wellington Headquarters.

For most of the visitors the highlight of the weekend was the 20-mile trip up the Wanganui River by launch to Hipanga Park and visits to Wanganui listening posts. It was resolved that the 1948 Conference be held in Wellington.

Officers elected for 1947-48 were: President, B. Beauchamp, Wellington; Vice-presidents, M. Kelly of Wellington, H. Bagley of Wanganui, and M. Tribe of Inglewood, Taranaki. The immediate past-president is Mr. A. Kindell, Wellington. Mr. J. Saunders was re-elected Headquarters Secretary (Wellington), whilst Mr. Chas. Brown (Wellington) was elected Treasurer. The Wellington personnel for Headquarters Committee are Messrs. Featenby and Jennings, whilst the Magazine Committee consists of Messrs. R. Free, M. Kelly, J. Saunders, Riley and A. Kindle. The Callbook Committee (Dunedin) consists of A. E. Greenway, E. Niven and A. L. Stanton. E. W. Watson of Christchurch remains the Publicity Liaison Officer.

Ron Greenwood, Managing Director of National Carbon Pty. Ltd., and Charles Hart, Sales Manager of the same Company, have both been in Australia—Ron on general business, whilst Charles attended a sales conference.

WOT, NO ROLA?



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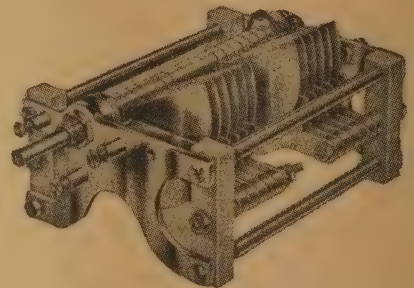


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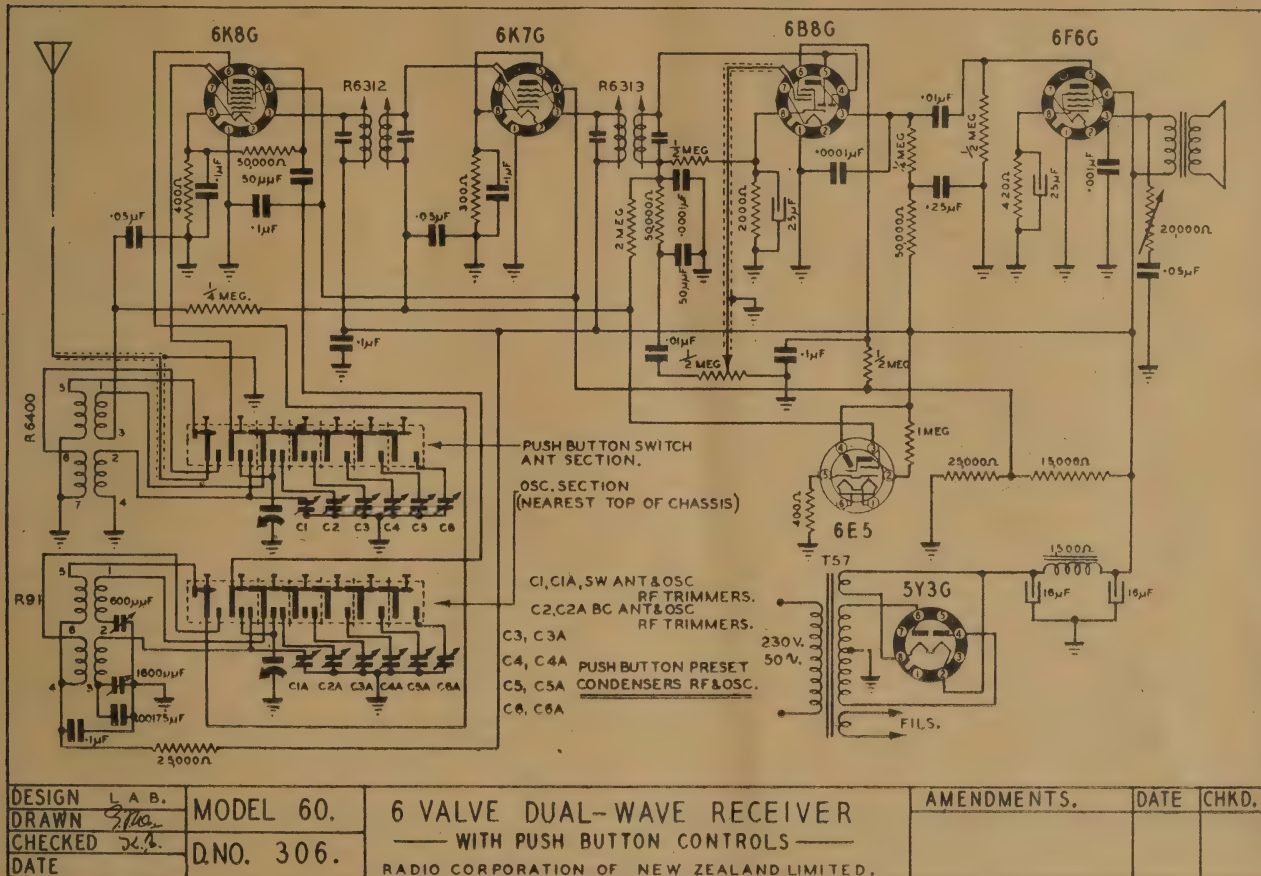
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FOR THE SERVICEMAN

COLUMBUS MODEL 60.—This circuit, Model 60, requires no special alignment instructions, except to note that the I.F. is 464 kc/sec.



PUBLICATIONS RECEIVED

We have received from the publishers a copy of the Australian magazine "Hobbies Illustrated," which is now on sale in New Zealand.

Devoted entirely to the "Hobbyist," this magazine maintains an outstanding interest in every possible

type of hobby—from butterfly collecting to home carpentry. It is difficult to produce a publication wherein readers of widely differing tastes can find articles to suit their particular requirements, but the editors of "Hobbies Illustrated" have obviously found the formula, and are to be congratulated on the excellence of the magazine.

MR. CORNEY INVESTIGATES



Well folks, you will notice that I haven't a new problem for you this month. I'm sorry about this, but all the receivers in the district seem to have gone wrong at once, and their owners want them fixed in next to no time. Still, unless the worst happens, I'll have one ready for you next month.

SOLUTION TO LAST MONTH'S PROBLEM

Brown's A.C./D.C. set?—oh, there wasn't much to it when we had dived about in the undergrowth and traced some logical path through the tangle, especially at the supply end which seemed to be the trouble centre as it looked like a case of modulation hum. It is common practice to fit an

R.F. by-pass condenser between the rectifier anode and H.T.—in such circuits especially if there is a current surge limiting resistor present. I spotted the resistor all right, but there was no sign of any associated condenser, so I bunged one in, making sure that its value was such as to be a virtual short to R.F. in comparison with the resistor and ?

Correct solutions to Case No. 1 were received from K. R. Orr, Auckland; J. I. Tidswell, Dannevirke; and D. Leonard, Auckland. None of their answers tallied exactly with mine—after all it was a pretty abstruse one, wasn't it?—but I must admit that the symptoms I gave allowed their answers to be considered correct.

A Practical Beginners' Course

PART 11

Last month's instalment finished with a description of the **thermionic effect** which, we said, makes valves possible. We saw how a hot piece of metal has round it an invisible cloud of electrons which have evaporated from the surface of the metal and which are prevented from escaping further by the strong attraction which exists between the electrons themselves and the atoms which have temporarily lost them.

In order to liberate electrons by the thermionic effect it is necessary to raise the metal to a very high temperature indeed—so high a temperature, in fact, that many metals would either melt or become oxidised by the air, or both, before appreciable numbers of electrons were liberated. Thus, if the thermionic effect is to be made use of, only metals which have a very high melting point are of any value to us. The problem of suitably heating a metal so that it gives off electrons without either melting or becoming burned is almost exactly the same as that of heating the metal sufficiently to become a useful source of light, so that we already find ourselves with something in common with the ordinary metal filament electric light bulb. This common object consists of a glass bulb, containing the metal to be heated in the form of a fine wire or filament made of **tungsten**, which is a metal having a very high melting point. The purpose of the glass bulb is to enable the air to be pumped out, leaving the filament in a vacuum. Now, since there is no air at all in the bulb, the filament may be heated to as high a temperature as we please without it becoming oxidised or burnt through being in contact with the oxygen of the air. If we raise the temperature too high, however, the filament will melt, but we take care not to do this by not passing too much current through it.

The simple device we have just described is the ordinary vacuum electric lamp globe, whose useful job in life is to provide us with light. This it gives, simply because the filament may be heated white-hot by the passage of an electric current without its either melting or burning away.

However, as Edison discovered many years ago, the heated filament is also a source of electrons by virtue of the thermionic effect.

HEATING EFFECT OF AN ELECTRIC CURRENT

We have referred above to the fact that passing an electric current through the filament of a lamp brings it to white heat, and no doubt readers will want to know why this happens. The fact is that if a current is passed through any conductor having resistance, the conductor becomes warmer. Just as friction between two surfaces produces heat, so does the electric current. The resistance of a conductor can therefore be likened to mechanical friction. In overcoming both these things, energy is used up and appears in the form of heat.

The heat produced by an electric current may be looked upon as the result of friction between the moving electrons and the remainder of the material in the conductor.

Not all conductors become hot when a current is passed through them, as, for example, the connecting wires in a radio set or the house-wiring through which we get our electric supply. This is simply because the resistance of these conductors is so low that the amount of current passed through them is insufficient to cause a measurable rise in their temperature.

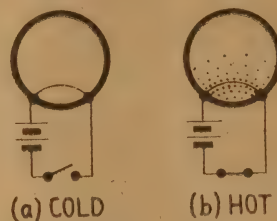


FIG. 14

At this point it should be made clear that the actual resistance in ohms of a piece of metal depends not only upon the material of which it is made, but upon its shape. For example, suppose we have two separate ounce blocks of copper. One of them we make into a short thick rod an inch or two long, and the other we make into a mile of very fine wire. If now we take these two "wires" and measure the resistance between their ends, we will find that the short thick one has a resistance of a small fraction of an ohm, whereas the long fine one has a resistance of several thousand ohms. In each case we started off with the same amount of copper, so that the actual resistance is seen to depend on the shape of the piece as well as on its material. The two simple rules we have illustrated are these:—

- (1) If the thickness of a wire is held fixed, then its resistance will be proportional to its length.
- (2) If the length is held fixed, and the diameter is varied, the resistance will be greater the finer the wire.

This explains why wire-wound resistors are made of the finest possible wire, because doing so reduces the length that needs to be used to give a specified resistance. We can now go back to our original story about electric lamps and valves.

FROM A LAMP TO A VALVE

Fig. 14 gives a diagrammatic representation of an electric lamp, together with a battery to heat its filament, and a switch to turn it on and off. The thick black circle represents the glass envelope, from which the air has been pumped out, and the thin curved line inside the "bulb" represents the fine wire of the filament. No one would suggest that a lamp actually looks like this, but Fig. 14 is simply a convenient way of illustrating the construction.

In Fig. 14 (a), the switch is open. Thus, no current flows in the lamp circuit, and the filament remains cold.

In Fig. 14 (b), however, the switch has been closed. This allows the battery to send a current through the filament, and in a very short space of time the latter has become white hot and glows brightly. At the same time the thermionic effect comes into play, and the heated filament becomes

surrounded by electrons which have evaporated from the filament, and form a cloud all round it. This cloud is illustrated in Fig. 14 (b) by dots, which by their density show where most of the free electrons congregated—nearest to the filament.

The filament is now said to have **emitted** electrons, and the phenomenon illustrated in Fig. 14 (b) is properly known as **thermionic emission**.

POSITIVE AND NEGATIVE CHARGES

Before going any further it is necessary for us to learn a new term—that of electric **charge**. When we were talking about the way in which a cell generates a current, we said that at one terminal the chemical action in the cell causes a dearth of electrons, and on the other terminal an excess of them. This dearth on one and excess on the other represents the electrical pressure, or voltage, of the cell, which tries to force electrons to flow round outside the cell from one terminal to the other. Another and simpler way of saying all this is that the terminal which is short of electrons is **positively charged**, while the one with too many electrons is **negatively charged**. There is no good reason why the names **positive** and **negative** should have been adopted, except that they indicate things of opposite kinds, nor is it necessary to have the names this way round. The terms positive and negative came to be used long before the existence or nature of electrons was known, when it was thought that electricity was of two kinds, so that the old names have been kept on, and now mean what we have stated above.

Any object, metallic or otherwise, can be **positively** or **negatively charged**. One that is positively charged

is simply one which has had some of its electrons removed, while a negatively charged object has more than its fair share of electrons. Thus, electrons themselves are charged negatively. In fact they are often described as free negative charges of electricity.

The important practical point about charged objects or **bodies** as they are usually called, is that a force of attraction occurs between bodies that are oppositely charged, while those that are similarly charged exert a force which makes each repel the other. It is quite easy to see why when it is remembered that if a positively and a negatively charged body are brought together, the charges will naturally tend to neutralise each other, and will do so exactly if the one has lost exactly as many electrons as the other has surplus. In all natural phenomena, any changes which take place of their own accord do so in such a way as to restore the natural state of affairs. Thus the uncharged state is the natural condition of all objects, and the state of being charged must be brought about by some external agency. Thus it is that oppositely charged bodies attract each other. Similarly, two negatively or two positively charged bodies repel each other, since if they are brought together, a larger charge than before is caused to exist.

ADDING A PLATE

In Fig. 14 we saw how a filament enclosed in an evacuated glass bulb can be made to act as a source of free electrons, by simply passing enough current through it from the filament battery to make it emit electrons. So far we have made no attempt to use these electrons.

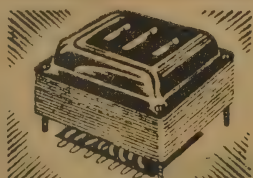
Suppose now that we place a plate of metal inside

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the bulb, as in Fig. 15, in which our new lamp is drawn diagrammatically. First of all we will disregard the lower diagram in Fig. 15 and talk about the top one only. As well as placing the plate inside the bulb, we have taken a second battery and an electric meter and connected them in series. The battery and the meter have then been connected from the plate to the filament. The purpose of the meter is to tell us whether or not any current is flowing in the circuit of the second battery. Now, looking at both parts of Fig. 15, we can see that

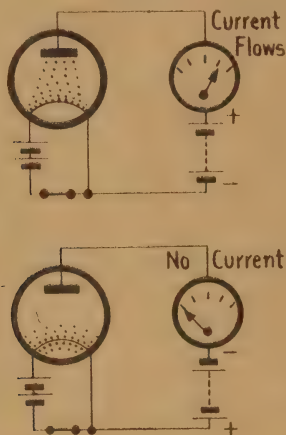


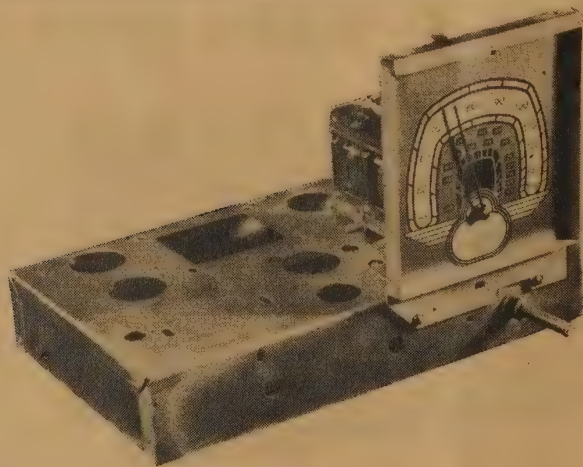
FIG.15

there is only one difference between the two circuits. In the top one the positive terminal of the new battery has been connected to the plate, and the negative one to the filament. In the bottom circuit the direction of the battery connections has been reversed.

Fig. 15 also shows us what happens when these two different connections are made. In the top diagram, the meter needle has swung over, showing that an electric current is flowing through our new battery. In the bottom one, the meter pointer remains on the zero mark, showing that no current is flowing. What is the reason for this behaviour?

In the top picture, the plate inside the bulb is attached to the positive terminal of the battery. The positive terminal is the one that is short of electrons, and is therefore positively charged. Now, connecting the plate to it has made this positively charged, too. In our bulb we now have a number of freed electrons, as in Fig. 14 (b), and a positively charged plate, which as we have seen, will attract the electrons. These therefore move towards the plate where they strike it, and allow a current to flow round the circuit. In other words the bulb completes the battery circuit just as a piece of wire would do, and allows a current to flow, and be registered on the meter.

Now let us consider the lower diagram in Fig. 15. This time, the battery is connected round the other way, and the plate inside the bulb is therefore negatively charged. This causes the free electrons inside the bulb to be repelled from the plate, so that none of them are able to move through the bulb, but only to go back towards the filament from which they were emitted. Thus no electrons can move round the



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battery circuit, which is the same thing as saying that no electric current flows.

Here then is the peculiar property of our specially arranged lamp. It allows current to flow in it **in one direction only**, and not in the reverse direction. We have, in effect, a **valve** similar to the valve in a pump, which allows water or air to flow one way, but not in the reverse direction. This is why the term valve came to be used to denote a device such as we have described.

This simple gadget consisting of an electric lamp with a metal plate inside it was the first radio valve to be invented. Properly speaking it is a **diode** which is a name meaning a valve containing two elements or **electrodes**. The filament is one electrode and the plate is the other.

The first use to which the diode was put by its inventor Dr. Fleming (who died only last year) was to replace the crystal detector in the simple radio receivers of the early 1900's. How such a valve is able to function in the same way as a crystal detector we are not yet in a position to explain, because in this course we have not yet attempted to explain how a crystal detector works. However, at the moment it will be enough to say that both the crystal and the diode, when used as detectors of radio currents, are successful because each has the property of passing a current in one direction only. The big advantage of the diode over the crystal detector is that as a valve it is much more efficient, and at the same time is much more reliable.

With a diode, all that is necessary is to turn on its filament battery and it works—as long as the battery lasts—and there are no awkward adjustments to make as there are with the crystal detector.

(To be continued.)

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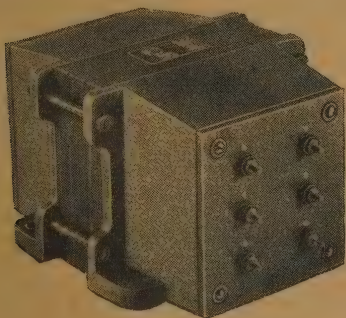
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TRADE WINDS

The Book of British Radio Components

By Stanley H. Nelson

A trade publication of great value to all radio interests in the world has been issued in Britain.

The part played by Britain's Radio Component Industry in bringing British Radio to its present world leadership in scientific research, technical design and excellence of workmanship is too well known to need emphasis, but the official export catalogue of British Radio Components, just published, will be a valuable addition to the information sections of radio manufacturing interests all over the world.

Besides telling the fascinating story of British Radio with particular reference to the achievements of the Radio Component Industry, its 184 pages contain an alphabetical index of Radio Components and the names and addresses of manufacturers, a review of the principal products and an alphabetical list of trade

names. The information pages are printed in three languages—English, French, and Spanish. It is published by the Radio Component Manufacturers' Federation, of 22 Surrey Street, Strand, London, W.C.2, a body which embraces over one hundred member firms, representing 95 per cent. of the British Radio Component Industry, with a combined capital investment of over £14 million, employing upwards of 60,000 people and occupying factory floor space exceeding six million square feet. This efficiently organised industry covers a wide field of technical development embracing radio, television, communications, radar, and electronics.

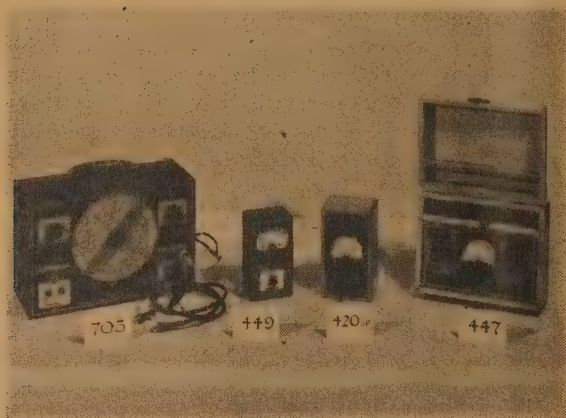
With the aid of the Radio Component manufacturers, the British Broadcasting Corporation in 24 years has built up the vast organisation now recognised throughout the world as the model broadcasting system, and in 1936 operated the world's first regular television system.

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the British Radio Component Industry was increased nearly fourfold, total output amounting to several millions of equipments and hundreds of millions of components. Every heavy bomber of Britain's Royal Air Force carried eleven separate equipments and employed two-and-a-half miles of cable. In addition, every light and medium bomber and every fighter, transport aircraft and trainer carried its quota of communication and radar sets. The total output of British aircraft exceeded 120,000. The Army, in addition to the employment of radio and radar in tanks, landing craft and armoured cars used hundreds of thousands of radio telephone sets for airborne and other assault troops. The high degree of standardisation achieved will have an important bearing on post-war production, while the fruits of those years of intensive research are now being harvested.

Research continues with undiminished intensity—into micro-waves, colour television and stereoscopic viewing, radio frequency heating, radio therapy, and a score of other fields.

To-day the demand for radio is enormous, thanks to its post-war expansion plus the restriction of commercial production during the war years. The British Radio Component Industry is admirably equipped to meet this demand. It is highly mechanised, efficient and versatile and geared to produce radio, communication and electronic components designed to operate at peak performance in any climate and under the most adverse conditions.

The overseas buyer will find full details of these products in this comprehensive catalogue and reference book.

EVEREADY AND BLACK-OUT CONDITIONS

On calling on National Carbon Pty., Ltd., we found phenomenal activity in producing refills to take care of the greatly-increased demand for all types of refills caused by recent black-out conditions.

We discovered that adequate supplies are coming forward to take care of the anticipated demand, and also that it is possible the manufacturers may extend the date-line labelling to other types of refills—probably Type 701 cycle refills. For these reasons, it would be unwise for dealers to carry more than their normal stock, plus sufficient refills to take care of immediate requirements, as the public are rapidly becoming date-line conscious as far as batteries are concerned.

It should be remembered also that there are 2500 dealers carrying stocks of Eveready in New Zealand.

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and if every dealer, due to the present power situation, carries supplies far in excess of normal requirements, it is obvious that, if black-out conditions are relieved, dealers who are over-stocked may be faced with a difficult problem.

CLASS A AMPLIFIER DESIGN

(Continued from page 9.)

sine-wave, it is clear that the amplitude of the positive half-cycle is the same as that of the negative half-cycle. It will be noted on Fig. 2 that the valve curves are not straight, parallel, and equi-distant, except at comparatively high voltages and currents. Thus, if the load-line cuts the more curved portions of the curves, the distance from Q to A becomes no longer equal to the distance from Q to B. This being the case (E max. — Eq) is no longer equal to (Eq — E min.), which is the same thing as saying that the positive and negative half-cycles of the output waveform are unequal in amplitude. Thus, distortion has taken place. The problem of using the curves to design a resistance-coupled amplifier is simply that of choosing the load resistance and the grid-bias to give a stated amount of distortion at maximum output, or for a minimum of distortion at a given output voltage.

(To be continued.)

ZL3AW AT HOME

(Continued from page 11.)

doors open at each side of the cabinet. All wiring between panels is enclosed in a channel in which panels exist for inspection of the junctions.

The cabinet is mounted on wheels and plugs are provided for all A.C. leads, aerial, etc., so that when the transmitter is moved there are no trailing leads to get in the way.

The transmitter was constructed in 3AW's own workshop, except for some of the chassis work, and took a year to design and build. Its owner thinks it was well worth the trouble, however, since he has worked 300 stations outside New Zealand in the space of two months.

The tower shown in the photographs mounts a 3-element 10m. Yagi array. It is constructed of 3 in. x 3 in. oregon for the uprights, and 3 in. x 1½ in. oregon for the cross-members, the whole being bolted together with galvanised steel straps. The array is rotatable through 360 degrees, slip-rings being used to connect the upper part of the feeders to the lower portion. The radiators are made of ½ inch copper rods which are adjustable in length. They are mounted on stand-off insulators attached to a spruce framework constructed of 2 in. x 1 in. timber. The upper and lower bearings of the rotatable portion are made from an old brake-drum, to which a ball race has been fitted, and from a ball race from a rear axle. The beam is mechanically driven by a ¾ in. galvanised pipe which runs up the centre of the tower. A small handle inside the transmitting room drives this vertical shaft through a reduction gear made from an old Ford rear end.

An interesting feature of the rotating array is the position indicator, which consists of sixteen lamps, arranged to show which sector the beam is in, and operated by a switching system attached to the main drive at the bottom of the tower.

ENLARGED 6A3 AMPLIFIER

(Continued from page 18.)

MODIFICATIONS

It is possible to visualise a number of modifications that readers may wish to make to this circuit, but of these, only two will be discussed here. First, if the extra gain given by the first half of V_1 is not required, V_1 may be replaced by a single 6J5, using exactly the same circuit as the second half of V_1 , and, of course, omitting the input switch, if only one input is desired. The only point to watch if this is done, is that R_4 must be raised to twice the value shown, for it will now have only half the current flowing through it. The other point is that of using a P.M. speaker instead of an E.M. one as shown. This can be done by substituting a 750 ohm 10 watt resistor for L_1 , the speaker field, or, if hum is troublesome, a choke, externally mounted, may be used instead. If so, sufficient resistance must be placed in series with the choke to bring its resistance up to 750 ohms.

ELECTRONICS IN METEOROLOGY

(Continued from page 6.)

terminals in bad weather with small petrol margins.

For these reasons meteorological services throughout the world have considered it necessary to install a considerable network of stations that make both radiosonde and radiowind observations, and as all meteorological services belong to an international organisation, these stations are placed, or are planned to be placed, in strategic positions so as to give as complete a world-wide coverage as possible. In New Zealand, for example, such stations are located at Auckland and Hokitika, and a further station is planned for Invercargill, while the authorities concerned are planning to establish several other stations in the Pacific Islands within a 1000-mile radius of New Zealand.

(To be continued.)

QUESTIONS AND ANSWERS

(Continued from page 37.)

transformer, bringing the high impedance across the tapping points down gradually to 600 ohms at the beginning of the line proper.

It is rather doubtful whether the perspex spacer would have enough strength to support the aerial itself. It is suggested, therefore, that a 3-inch Pyrex strain insulator be used at the centre of the aerial, and the perspex spacer be hung immediately beneath the insulator. In this way, the spacer would have to support only the strain on the quarter wave transformer, which will not be great.

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FOR SALE: "Hiker's Two" in blue cabinet with batteries and speaker. Price £10 or offer. Apply R. Garmonsway, Raetihi.

WANTED: January, 1946, issue of "Radio." H. Cox, 15 Firth Street, Cobden.

RADEL DUAL WAVE 6

(Continued from page 36.)

speaker should be plugged in and the set turned on. It is not intended here to detail the lining-up procedure, since the manufacturers of such coil units as we have used normally include with the units a sheet of alignment instructions. If these are followed carefully, no difficulty should be encountered in getting the set to "perk." It is still a good plan, however, once the rough alignment has been performed by ear, to take the set to some friend or serviceman who has a service oscillator, and get him to align the I.F. stages accurately to 465 kc/sec.

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